National Centers for Coastal Ocean Science (NCCOS)

Retreat Report
Williamsburg, VA
October 7-9, 1998

National Oceanic and Atmospheric Administration
National Ocean Service
1305 East-West Highway
SSMC 4, 13th Floor
Silver Spring, MD 20910
301-713-3060

Table of Contents

Introduction

I would like to take this opportunity to thank all who helped with and participated in the first NCCOS Science retreat held last month in Williamsburg, VA. As I said during my opening remarks at the retreat I would like to see NCCOS recognized as the place where managers and operations folks come for scientific expertise; an organization with strong internal programs that nurture the best scientists and produce thoughtful and comprehensive insight into how coastal systems work; and a place with strong extramural programs that bring academic and federal scientists together to tackle the big problems confronting us today, as well as those on the horizon. NCCOS should be the place where emerging issues and opportunities are brought to light; where organizational, political, and disciplinary boundaries are ignored; and where a diversity of views and opinions are encouraged and protected; where opportunities for professional growth abound, such that "the best" in the country want to come here to work. In short, NCCOS should be a place where credible, reliable, and innovative scientific output is produced. And "the place to work" if you're interested in a coastal or Great Lakes scientific career.

Our three objectives for this retreat were:

1. To get to know each other better; increase interactions among Center Scientists; find connections and potential areas of cooperation; and develop a sense of NCCOS.

2. To discuss and revise our Strategic Plan. Our plan should be a clear statement of what we are all about, where we are heading, and how our culture works.

3. To prepare the groundwork for NCCOS program direction and budget initiatives.

Given what I saw in Williamsburg and in the follow-up work that has been done so far, I believe we were successful in meeting those objectives. Over the course of the retreat we developed a better understanding of the organizations within NCCOS, expanded knowledge of other NCCOS scientists with similar research interests, and renewed the energy and confidence needed to pursue cross-NCCOS and cross-NOS science, supporting NOAA's coastal missions. Some of the participants immediately recognized others in complementary research fields and initiated discussions to work collaboratively in the future.

As a follow-up to the retreat, we have produced this report which summarizes the results. You will notice that it contains two parts. Part one contains most of the documents and information produced for and during the retreat, including center descriptions, speaker presentations, and group discussions. Part II is the result of some preliminary analyses done by my staff where they have identified common elements among the groups, as well as possible combinations for new initiatives.

Once again, I believe this retreat was a big success. Tremendous energy and enthusiasm for the new science office was generated. We must now work hard to live up to your high expectations. Please feel free to contact us with comments or questions

PART I

National Centers for Coastal Ocean Science

The National Centers for Coastal Ocean Science (NCCOS) conduct and support monitoring, research, assessment, and technical assistance within the range of NOAA's coastal mission. With the expertise of its Centers and their partners, NCCOS has taken the lead responsibility for several national and regional programs, including the National Algal Bloom Program and Harmful Algal Bloom Program, the Gulf of Mexico Assessment, South Florida Restoration activities, the Report Card on the Nation's Ecosystems, the Coastal and Marine Climate Assessment, and the CENR Ecosystem Initiative.

Established within the National Ocean Service (NOS), NCCOS hosts the NOS Senior Scientist, who is responsible for (1) overseeing NOS coastal science with a focus on integration and quality control of programs, processes, and products; (2) providing leadership for scientific interactions with programs inside and outside NOAA; and (3) coordinating the research, monitoring, and assessment functions of NOS' coastal and ocean activities.

NCCOS currently includes four Centers:

1) Center for Coastal Environment Health and Biomolecular Research (CCEHBR)

2) Center for Sponsored Coastal Ocean Research (CSCOR)

3) Center for Coastal Monitoring and Assessment (CCMA)

4) Center for Coastal Fisheries Habitat Research at Beaufort (CCFHRB)

and the proposed fifth Center,

Great Lakes Environmental Research Laboratory (GLERL).

Center for Coastal Environmental Health and Biomolecular Research

The Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) at the Charleston Laboratory in South Carolina, specializes in providing scientific information in the areas of biotechnology, marine biotoxins, ecotoxicology, marine forensics, marine lipid chemistry, and marine mammals and protected resources to support NOAA's role in fisheries management, seafood safety, habitat utilization and protected species issues.

Marine Forensics

Law enforcement support, unusual mortality investigations, and marine lipid chemistry form the basis of this program. Together, these efforts help to resolve marine forensic issues through integrative strategies using morphological evaluations, biochemistry, chemistry, and genetics. Forensic science principles are applied in support of law enforcement for the conservation and management of marine resources, with emphasis on protected and managed species, and investigations into ecological insults that result in adverse effects on the marine resource and their habitat.

Risk Assessment

Evaluation of human health risks associated with environmental contaminants in fish and shellfish provides risk management options for use by fisheries resource managers, public health agencies and seafood consumers. Research is focused on the environmental fate of chemical contaminants, marine biotoxins, and microbial pathogens in aquatic systems and their accumulation in marine biota. Objectives also include developing improved methods to determine the exposure of target populations to toxic or infective agents and using risk assessment models that incorporate public health needs, harvest options, and economic factors. Communication on seafood safety to consumer and industry groups as well as seafood regulatory personnel.

Managed and Protected Resources

Working to improve the management and conservation of protected species, the project responds to marine mammal and sea turtle strandings. Stranded animals are necropsied to collect tissues for contaminant and histopathology to determine the cause of death. Trends in strandings such as geographic location and lengths of animals along with other life history data are closely monitored. Research is centered around determining health assessment parameters and population dynamics through photo-identification studies and molecular genetics.

Marine Ecotoxicology

Toxicology, chemistry and ecology issues, pertinent to the marine and estuarine habitats of the Southeastern U. S. are the focus of Marine Ecotoxicology. A major goal is to establish linkages between land use and the presence of chemical contaminants in the marine environment.

Interdisciplinary research is focused on identifying chemical and bacterial contaminants associated with anthropogenic inputs from agriculture, urbanization, dredging operations, and industrial discharges and their resulting toxicological and ecological impacts on marine and estuarine ecosystems.

Marine Biotechnology & Genetics

Questions in biodiversity, environmental health, marine and fisheries biology, and the development of products derived from the marine environment are all addressed through the application of molecular and cellular biology. Research focuses on rapid assay development, discovery of biomarkers to assess resource and ecosystem health and molecular genetics. The Atlantic-Gulf Genetics Center (TAGG), functions within the Biotechnology Program to provide a genetic context for critical management and enforcement decisions for the long-term conservation and use of living marine resources.

Pathobiology

Scientists investigate the role of disease in the distribution, abundance, marketability, and edibility of marine animal resources, determine the influence of natural and man-made environmental factors on the occurrence and persistence of diseases, and explore the use of marine animal health as an indicator of environmental health. Focus is on developing and applying histopathological, clinical, biochemical, and microbiological approaches to study diseases of shellfish, marine mammals and sea turtles. This work is conducted at the satellite NOS research facility in Oxford, MD.

Marine Biotoxins

The Marine Biotoxin Program conducts research and provides scientific guidance to promote the effective management of fisheries, public health and ecosystem health on issues related to marine biotoxins and harmful algae. Research is conducted on all of the major classes of marine biotoxins. Fisheries managements research is conducted through development of quantitative dockside tests, on board tests and production of toxin standards. Public health research is conducted by the identification of biomarkers of toxin exposure and assessment of the acute and chronic risks of exposure. Ecosystem health is addressed by studying the role of bacterial-algal interactions and identifying genetic markers for specific strains responsible for harmful algal blooms.

Chemistry

The Chemistry Unit engages in structural, organic, and analytical analyses of biologically active and anthropogenic molecules from marine sources. Structural identifications employ HPLC, MPLC, long column, and GC for purification and quantification of compounds such as marine biotoxins. Structural characterizations are executed in contemporary NMR facilities equipped with a Bruker 500 MHZ NMR and PE-Sciex API mass spectrometer and SGI computer modeling capabilities. The analytical component quantifies anthropogenic contaminants such as PCBs, PAHs, pesticides and trace metals in marine sediments, tissues and water using GC HPLC-fluorescence, Atomic Absorption (AA) and Inductively Couple Plasma (ICP) to assess the impact of development and urbanization on the flora and fauna of coastal systems.

Cooperative Oxford Laboratory (now under the Center for Environmental Health and Biomolecular Research (CCEHBR)

The Center also includes the Cooperative Oxford Laboratory in Oxford, Maryland, which is known for shellfish pathology and life history research. Scientists are currently taking an active role on studying the impacts of Pfiesteria in the mid-Atlantic region. Other research at Oxford is centered around the Chesapeake Bay with emphasis placed on: strengthening oyster disease research; initiating a habitat restoration program; and establishing a regional center for marine mammal and turtle strandings.

For more information on the Charleston Lab's research activities, please contact: http://ccehbrc.csc.noaa.gov/

<u>Center for Sponsored Coastal Ocean Research</u>

The Center for Sponsored Coastal Ocean Research (CSCOR), located in Silver Spring, Maryland, manages NOAA's Coastal Ocean Program and NOAA's involvement in the National Oceanographic Partnership Program.

Coastal Ocean Program

The Coastal Ocean Program (COP) is an important federal-academic partnership providing predictive capabilities for managing coastal ecosystems. COP seeks to deliver the highest quality science in time for important coastal policy decisions by supporting high-priority research and interagency initiatives related to NOAA's mission in three goal areas:

Coastal Ecosystem Oceanography

COP supports the conservation and management of marine ecosystems by improving ecological and oceanographic predictions for resource management. Studies focus on: 1) identifying critical processes that control replenishment of fishery resources; 2) deter-mining mechanisms that allow ecosystems to withstand stress from fishing; and 3) quantifying species interactions so models can be used in management decisions. Current efforts support fisheries management councils dealing with Bering Sea pollock, menhaden in the South Atlantic Bight, cod and haddock on Georges Bank, and salmon in the Pacific Northwest.

Cumulative Coastal Impacts

COP improves the scientific basis for managing coastal ecosystems through a series of regional watershed projects on the causes and impacts of multiple stresses on coastal land and marine ecosystems. Studies focus on: 1) developing indicators of physical, chemical, and biological stress; 2) predicting impacts of multiple stresses on living marine resources; 3) valuing natural resources in ecological and economical terms; and 4) predicting the outcomes of management strategies. Current efforts support coastal and natural resource managers dealing with multiple stressors in the Chesapeake Bay, Florida Bay and the Florida Keys, the Great Lakes; and southeast coastal ecosystems.

Harmful Algal Blooms/Eutrophication

COP is assessing the impacts of harmful algal blooms (HABs) and eutrophication on coastal ecosystems and habitats by leading a national interagency research program on the ecology and oceanography of HABs, coordinating a national HAB research and monitoring strategy, and developing new technologies for assessing and monitoring habitat degradation. Studies focus on: 1) developing the means to predict HAB development, persistence, and toxicity; 2) developing HAB prevention, control, and mitigation strategies; and 3) conducting a scientific assessment of the causes and consequences of Gulf of Mexico hypoxia.

What are the benefits of COP?

Continued population pressures on the Nation's coastal areas and ongoing changes in the environment will continue to stress our coastal waters, bays, estuaries, and the Great Lakes. While the need for data and information to address today's problems is pressing, COP has also set its sights on developing information for longer-range management and policy decisions at larger and more complex scales than are traditional. COP has done this in the belief that research helps solve today's problems, and, hopefully help prevent tomorrow's. COP research will help the U.S. respond to the major challenges of the next century and to balance the needs of economic growth with those of conserving the environment by:

- developing ecosystem-level scientific projects that are multi-disciplinary, long term, and evaluate the impact of multiple stressors on ecological functions

- providing predictive information to resource managers that will help conserve and restore important marine resources

- fostering HAB event response to safeguard public health, local economies, and coastal habitats

- transitioning successful research to NOAA operations

For more information on COP's research activities, please visit: http://hpcc.noaa.gov/cop/

National Oceanographic Partnership Program

The Center for Sponsored Coastal Ocean Research will also manage NOAA's involvement in the National Oceanographic Partnership Program (NOPP). Research in the NOPP is cross-cutting, involves all the federal agencies with ocean and coastal responsibilities, and will focus on: cumulative coastal impacts, coastal and ocean observation and prediction, data access and delivery, and marine education.

For more information on the NOPP, please visit: http://core.cast.msstate.edu/NOPPhp1.html

<u>Center for Coastal Monitoring and Assessment</u>

The Center for Coastal Monitoring and Assessment (CCMA), located in Silver Spring, Maryland, was initiated to monitor, survey, and assess coastal environmental quality. This new Center is combining the expertise and resources from the NOS Office of Resource Conservation and Assessments (ORCA) Coastal Monitoring and Bioaffects Assessments Division (CMBAD) with many of the staff from ORCA's Strategic Environmental Assessments Division (SEA). CCMA's considerable expertise will include NOAA's National Status and Trends Program, the Biogeography Program, and the Physical Environments Characterization Program. These programs bring extensive national databases, Geographic Information Systems (GIS), coastal assessments, and more than 700 books, atlases, journal articles, and agency technical memoranda published on coastal monitoring and assessment to CCMA. This expertise and information will be used to support NOAA's coastal stewardship role in sustaining healthy coasts, providing safe navigation, and supporting fisheries management (e.g., the determination of essential fish habitats).

National Status & Trends

In 1984, NOAA initiated the National Status and Trends (NS&T) Program to determine the current status of, and to detect changes in, the environmental quality of our Nation's estuarine and coastal waters. Managed by CMBAD, the NS&T Program (1) conducts long-term monitoring of toxic contaminants and other environmental conditions at more than 350 sites along US costs, (2) carries out regional surveys to determine the magnitude and extent of the biological affects caused by these conditions, (3) partners with other agencies in a variety of environmental activities, and (4) advises and participates in local, regional, and international projects related to coastal monitoring and assessment. This is the longest-running Federal coastal environmental quality monitoring program in the US. It is also flexible and robust, providing information on the status and trends of chemical concentrations as well as radionuclide monitoring, historical trend determinations in sediment cores, benthic community composition and diversity, sediment toxicity, biomarker studies, and endocrine disrupter research.

For more information on the National Status and Trends Program, please visit: http://www-orca.nos.noaa.gov/projects/nsandt/nsandt.html

Biogeography of Living Marine Resources

The Biogeography Program provides managers and scientists with information on living marine resource distributions and ecology throughout the nation's marine, coastal, and estuarine environments for improved decision making regarding coastal ecosystem sustainability and resource management. The Program is focused on developing information on the distribution of living marine resources, habitats, and the affinities of species for particular habitats. In agency partnerships (e.g., States, Regional Fisheries Management Councils, National Marine Fisheries Service, US Fish and Wildlife Service), Quantitative Habitat Suitability and Habitat Affinity Indices models coupled with digital maps of environmental parameters have been integrated via GIS technology. The coupling of GIS with biogeography enables characterization of essential fish habitat to aid in the management of marine fisheries. This work utilizes information from the Estuarine Living Marine Resources (ELMR) Program in which over 6,000 species estuary data sheet combinations have been compiled and peer reviewed for 135 species in 122 continental US estuaries. This information has many applications and is available in digital map and tabular formats.

For more information on an example of the Biogeography Program's projects,
please visit: http://christensenmac.nos.noaa.gov/gom-efh/

Physical Environments Characterization

The Physical Environments Characterization Program collects, synthesizes, and analyzes data on the physical and hydrological features of the nation's estuaries and coastal areas. This program maintains and updates information that characterizes freshwater inflow, salinity, susceptibility to nutrient inputs, and eutrophication potential within US estuaries.

CCMA will retain its priority coastal contaminant monitoring and assessment activities and will build the capacity to assume an increasing role in assessing related environmental conditions (e.g., eutrophication and harmful algal blooms, field testing new techniques and tools for environmental observation, employing satellite and moored buoy surveillance of coastal change, and conducting national and regional assessments of major coastal environmental issues). It will retain and update the ELMR data and have an increased role in habitat assessments. In addition, it will continue to advance its habitat suitability model effort using GIS by linking quantitative fisheries data with the distribution of habitats via GIS technology.

Center for Coastal Fisheries Habitat Research

The Center for Coastal Fisheries Habitat Research (CCFHR), located in Beaufort, North Carolina, had its beginnings in 1899 and is the second oldest Federal fisheries laboratory in the United States. The Beaufort Center's strong national expertise in coastal and estuarine fisheries habitat research will help in achieving NOS' objective of becoming the premier federal coastal management and research agency. Current research at the Beaufort Center is focusing on: estuarine processes, nearshore and ocean ecosystems biological productivity, the dynamics of coastal and reef fishery resources, and the affects of anthropogenic influences on resource productivity. The Beaufort Center's primary goal is providing resource managers with information necessary to enhance recreational and commercial fishery resources and to address Essential Fish Habitat information necessary under the Magnuson-Stevens Fishery Management and Conservation Act including scientific information on:

- Biological productivity and cycling of contaminants in the southeast and Gulf;

- Affects of habitat modifications and contaminants on fishery resources;

- Distribution and temporal changes in Essential Fish Habitat through interpretation of aerial and satellite photography and use of associated ground truthing;

- Factors controlling ecological values and utilization of coastal and estuarine habitats;

- Sea surface temperatures to establish fishing zones to protect sea turtles;

- Optimum fishing rates and population response to various rates of fishing; and

- Protected species (e.g., sea turtles and mammals) populations, their life histories, and their habitats in the inshore and nearshore ocean waters off North Carolina.

Water and Habitat Quality

The Beaufort Center is providing scientific information, particularly in the areas of water quality and habitat value based on ecological and contaminant-related research. The Beaufort Center is also conducting research on toxic marine algae. Research is frequently conducted in partnership with researchers from academic institutions, and state and federal agencies. The Center provides scientific data and advice on habitat impacts (both physical and chemical), approaches to impact minimization, and restoration to state agencies, the US Army Corps of Engineers, US Fish and Wildlife Service, and NOAA.

Damage Assessment and Restoration

The Beaufort Center was instrumental in the establishment of the NOAA Restoration Center which is a component of the NOAA Damage Assessment and Restoration Program (DARP). Researchers at Beaufort provide scientific information to DARP on impacts to Essential Fish Habitat, conduct research designed to develop restoration protocols and plans, and serve as expert witnesses for NOAA General Counsel and the Department of Justice. For example, Beaufort Center staff recently provided scientific data and expert witness testimony in two precedent setting cases in the Florida Keys National Marine Sanctuary and Laguna Madre dealing with the impact and restoration of seagrass habitat.

Fishery Management Support

The Beaufort Center is also actively engaged with federal and state fishery management entities in support of fishery resource management under the M-SFCMS, Atlantic Coastal Fisheries Cooperative Management Act, and Interjurisdictional fisheries. Species of concern have included Spanish and king mackerel, golden crab, wreckfish, weakfish, striped bass, Atlantic sturgeon, horseshoe crab, bluecrab, etc. Research also is conducted on the biology and community dynamics of reef fish along the Atlantic coast from North Carolina to Florida.

If you'd like more information on the Beaufort Center's research activities, please visit: http://www.sefsc.noaa.gov/public/bea.html

<u>Great Lakes Environmental Research Laboratory</u> (proposed fifth center)

The Great Lakes Environmental Research Laboratory (GLERL), located in Ann Arbor, Michigan, was created in 1974 to provide a focus for federal research on the Great Lakes. GLERL conducts integrated, interdisciplinary environmental research in support of resource management and environmental services in coastal and estuarine water, with special emphasis on the Great Lakes. The proposed addition of GLERL will boost NOS' presence in the Great Lakes, while also giving NOS an outstanding center for multi-disciplinary oceanographic research. Current GLERL research is providing Federal, State, and international decision and policy makers with scientific understanding of:

- The sources, pathways, fates, and effects of toxics in the Great Lakes;
- Natural hazards such as severe waves, storm surges, and ice;
- Ecosystems and their interactions, including the implications of invasion by nuisance species;
- The hydrology and water levels of the Great Lakes; and
- Regional effects related to global climate change.

Water Quality

GLERL researchers have contributed to important Great Lakes policy issues, especially with regard to water quality. A key phosphorus model that was used to determine phosphorus load reduction policies in the late 1970's was developed at GLERL, which ultimately saved the American taxpayer several billion dollars. GLERL scientists involved in evaluating processes affecting the deposition and cycling of contaminants in the lakes showed that the sediment zone is a major repository for contaminants and also a major source for recycling contaminants to the water column. More recently, GLERL's Aquatic Contaminants Program is contributing to the development of national protocols for assessing contaminated sediments, including newly initiated studies in Lakes Michigan and Superior.

Nonindigenous Species

GLERL is also actively involved in research on nonindigenous species, specifically the zebra mussel in the Great Lakes, impacts of climate change on the Great Lakes and mid-U.S. water resources, development of coastal environmental forecast systems, Great Lakes water supplies, water level forecasting and regulation, use and dissemination of satellite imagery for environmental products development, factors that effect and determine the bioavailability of toxic organic chemicals, environmental reconstruction (retrospective analysis) from sediment core records, ecosystem and water resources problems of south Florida - the Everglades and Florida Bay, and the seasonal hypoxia in the northern Gulf of Mexico.

If you'd like more information on the GLERL's research activities, please visit:
http://www.glerl.noaa.gov/

THEME TOPICS and GROUP REPORTS

This section contains information pertaining to the ten theme topics, including speaker presentations (which set the stage for break-out group discussions), summaries from the break-out group(s), and the group presentations.

The ten theme topics were identified from:

- draft NOS and NCCOS strategic plans,
- ideas that were floated by the Centers and others during the FY 2000 budget process,
- priority activities in the White House Office of Science and Technology Policy, and
- discussions with the Center Directors on hot topics, lasting topics, and emerging topics.

They were intended to be provocative and help shape group discussions. They were not meant to constrain those discussions and they clearly are not mutually exclusive, which is one reason why we designed two independent breakout sessions for each topic. It was our hope that the overlapping discussions carried from the first break-out group to the second would help to eventually condense these topics into a smaller number of integrating themes.

The purpose of the break-out groups was to develop the elements of NCCOS initiatives for monitoring, research, modeling, and assessment in each theme area. To aid in developing that context, each group was asked to consider the following questions:

1. What are the key issues related to this theme?

2. What are the essential information and tools decision makers need to address these issues?

3. What are the scientific and technological impediments to developing and delivering this information and tools to the decision makers that NCCOS can/should address (particularly those that cross-cut NCCOS capabilities)?

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome those impediments?

For each topic the presentation of material begins with the summary of the speaker's talk, followed by the notes from break out groups I and II, and ending with the final group presentation. In some cases the group II and final summaries are one in the same.

1. Coastal Environmental Indicators

Complex coastal ecosystems are heavily influenced by human and natural events. The impacts of these events occur at the genetic, organismal, and ecological levels of the ecosystem with resultant affects observed as the cumulation of these multiple stressors. The development of coastal environmental indicators or tools (e.g., biomarkers, probes, etc.) for tracking ecosystem responses to these stresses are needed to monitor trends in ecosystem health.

Speaker:	Jawed Hameedi (CCMA)
Group I Chair:	Gretchen Messick (CCEHBR, Oxford)
Group II Chair:	Tom Nalepa (GLERL)
Recorder:	Gloria Seaborn (CCEHBR, Charleston)

1.1 Speaker Summary

Jawed began his presentation by giving two examples of indicators. The first, a relatively straight forward situation: the first appearance of the bluegreen alga Oscillatoria rubescens as a precursor of eutrophic conditions in a lake. For the second example he used blood lead levels in children and adults, and discussed the complexity in interpretation for a situation where a certain segment of the affected population is impacted differently (children vs adults) at similar levels, and the long-term implications of lead contamination.

He provided a definition of indicators and examples, including those ranging from the subcellular to the ecological level.

A comprehensive list of useful biomarkers was presented as well as specific bivalve biomarkers.

Jawed emphasized the widespread use of indicators and stated that virtually everyone, from US government agencies to international organizations, wanted indicators. He provided examples of indicators developed in response to government requirements, and those used in academia to elucidate complexity of ecosystem organization.

He stated that indicators often take the form of an "index", or number, for use in ranking locations, trend analysis, resource allocation, public information, and scientific research.

Using the Dow Jones as an example, he explained that methods used for determination of an index may sometimes be arbitrary. Related issues and impediments were addressed.

Jawed closed by stating that NCCOS presents an opportunity for a cohesive interdisciplinary approach to further development and application of environmental indicators. He recommended multi-parametric, integrative approaches applied in a step-wise manner.

1.2 Group I

1. What are the key issues related to this theme?

- Establishing criteria for reference "impacted vs non-impacted"
- Establishing baseline
- Scaling problems: subcellular-micro-organisms-community
- Impact on long lived animals/plants
- How to work with natural variability in the environment, climate, etc.
- Making sure indicators have ties to societal cost.
- Distinguish between chronic and acute, as well as sublethal
- Consider use and mis-use of information developed on one level- not used or overly extrapolated to other levels
- Develop index which reflects impact to multi species
- Index developed should be useful to those who did not develop them.
- Need for new tools to develop data for indicators
- How does one decide on what 'element' will serve as an indicator,
- Reference envelope and normal range of indicator values needs to be established
- Scaling problems need indicators for biological organization examples
- Translate information for use by managers
- Chronic vs acute stressors
- Care in extrapolating to whole systems
- Must leverage influence with other agencies to make changes
- Coastal environmental changes are not always what is expected

2. What are the essential information and tools decision makers need to address these issues?

- Bioaffect threshold guide lines
- Need baseline information
- Understanding of system concerned about
- Need better tools, models for displaying indicators
- Better QA/QC of tools
- New risk assessment paradigm to express multi-stressor finding
- Need to define critical pathways and control points
- Need to communicate social values and benefits of healthy coastal environments
- Interpretive approach for differentiating between relative impacts of multi stressors (weight of evidence assessment approaches)
- Measure societal costs for major environmental issues
- Need indicator tools that lead to strongest link between 'cause and effect'

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- News media how do they become advocates -need education and outreach.
- Will indicators work on a complex system?
- Lack of funding continuity, institutional commitments for developing and applying indicators, proactive rather than reactive.
- Indicators alone cannot supply all the needed information on cause and effect, follow-up research needed
- Lack of information to determine what indexes should be used, esp. for multiple stressors
- Can't measure small incremental changes, need better sensitivity
- How to resolve conflicting information results from different indicators
- Tiered, multiple stressors, need suite of indicators
- Need to id key species
- Need to integrate data on different spatial scales, concern for resolving data at different spatial scales
- Lack of specific socio-economic data to assist in interpretation of indicators of impact of change.

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Dedicated focus to develop indicators that are suitable for ecosystem models, GIS etc.
- Identify appropriate indicators, methods for evaluation in context for their use
- Field experiments on impacted sites to test indicators along gradients of stress
- Set up demonstration sites and focus resources rather than disperse them.
- Make use of all relevant available data, including other government sectors, climate etc.
- Hypothesis driven experiments
- Interface capabilities of satellite image, land-use information, in-situ estuarine condition to draw linkages
- Better define 'healthy'
- Use NEERS/Marine sanctuary sites as demo sites plus other sites with long- term data available with environmental gradients.
- Should be done in phases:
  1. Define information needed
  2. Develop indicators, develop data for demonstration project, synthesize data available, collect historical information

  3. Using lab/mesocosm

  Important to have pilot studies for all data gathering information prior to larger hypothesis, testing activities

  4. Develop models

Statement:

Reliable indicators are essential for making effective decisions on coastal resource management. For maximum benefit, indicators should be developed and reported within the "Pressure - State - Response" framework which implies paradigms of causality and accountability. NCCOS should provide a budget to allow the development and validation of such indicators.

1.3 Summary Groups I and II

1. What are the key issues related to this theme?

- Coastal ecosystems are in a state of change
  - Degrading as a result of multiple human induced stressors
  - Improving as a result of remedial actions
  - Responding to natural events at various time scales
- Need to define how these changes are occurring on a temporal (decades, days) and spatial (sub regional, regional, national) scale
- Need to develop and assess tools to monitor these changes, and differentiate responses to multiple stressors and differentiate these responses from natural events
  - Define their application
  - Can they be field verified
- Specific to NCCOS:
  - What indicators or combination of indicators best provide an assessment of ecosystem health
  - What indicators would best fit into the mission and current research/monitoring activities of NCCOS?
  - Can we use our indicators as a guide to further research

2. What are essential information and tools decision makers need to
address these issues?

- Baseline information is needed to:
  - at various levels of organization (cellular, organism, population, community, ecosystem)
    - define critical pathways and control points
    - provide threshold effects
  - make interpretations and define approaches for differentiating between relative impacts of multiple stresses
  - provide indicator tools that lead to strongest link between ’cause and effect’
  - clear definition of the sensitivity of a specific indicator to a given stressor change-understand the system to which the indicator is applied
    - examples: top predator, keystone species, component of the ecosystem with the most societal/economic significance

- integrate the indicator into both an ecological and management framework

3. What are the scientific and technological impediments to developing and delivering this information and tools to decision makers that NCCOS can/should address?

- lack of agreement as to what indicators should be used and for what purpose
- difficulty in establishing long term commitments for indicators denoting changes over long time periods
- indicators alone cannot supply all the information needed
- indicator cannot be easily interpreted by anyone outside the person who developed it
- different indicators are telling different stories (degree of impact can vary)

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- dedicated focus to develop indicators that are suitable for ecosystem models, GIS, etc.
- long-term commitment to the use of indicators
- focus efforts to test indicators along known stress gradients emphasizing an integrative approach
- cannot be complacent as to what indicators we already have- continuous development and refinement
- assess indicators already present and define ways to make them more applicable given changing technologies

FINAL STATEMENTS:

Group 1:

Reliable indicators are essential for making effective decisions on coastal resource management. For maximum benefit, indicators should be developed and reported within the "Pressure-State-Response" framework which implies paradigms of causality and accountability. NCCOS should provide a budget to allow the development and validation of such indicators.

Group 2:

We should develop a program for the national evaluation of the status of coastal ecosystem health using a suite (≈6) of meaningful, responsive, and interpretable indicators.

2. Toxic Chemical Contaminants

A range of organic and inorganic chemical contaminants are of continuing concern to society (e.g., seafood safety, nonpoint source pollution, etc.). Research and monitoring programs improve our understanding of the levels and affects of existing contaminants on ecosystem processes (e.g. endocrine disrupters), as well as enable us to assess the affects of "new" contaminants on the coastal environment.

Speaker:	Geoff Scott (CCEHBR, Charleston)
Group I Chair:	Mike Fulton (CCEHBR, Charleston)
Group II Chair:	Tom O'Connor (CCMA)
Recorder:	Tim Tisch (NCCOS)

2.1 Speaker Summary

Introduction

Environmental stressors that impact ecosystem health:

- over-harvesting of natural resources
- introduction of exotic species
- toxic chemical contaminants
- physical habitat or landscape restructuring
- modification of natural perturbations
- single and multiple stressors

- the study of ecosystems under stress should yield early warning indicators
- practices should be preventive rather than diagnostic or curative
- toxic contaminant research should be conducted with a management objective in mind

Five New Areas for Research

New Classes

- contemporary use pesticides
- pharmaceutical drugs and chemicals (generally associated with human and animal wastes as well as aquaculture)

New Indicators

- new field indicators
- new laboratory assays (fish, crustaceans, mollusks, algae, etc.)
- mesocosms (provide a bridge between the lab and the field)
- early warning indicators

Cumulative Contaminant Affects

- cumulative ERLs/ERMs as predictors of cumulative contaminant affects
- importance of NOAA NERRS sites as reference sites
- ability to discern contaminant affects from non-contaminant affects

Endocrine Disrupting Chemicals

- phytoestrogens vs. xenoestrogens
- screening assays (several have been developed)
- crustacean models (need to have both vertebrate and invertebrate models)
- extrapolate to marine mammals and protected species

Linking Contaminants and Land Use Develop Effective Environmental
Management Strategies to Reduce Contaminant Loadings

- utilize land use modeling and GIS to detect land use changes in the coastal zone
- need linkages with hydrographic loading models to understand NPS run-off load of various watersheds
- need to couple with remote sensing capabilities
- need to take this data to government stakeholder groups, etc. to help them develop effective land use management strategies, BMP's, etc., so we can protect our coastal watersheds

2.2 Group I

1. What are the key issues related to this theme?

- Toxic contaminants act in concert with other stressors and only occur in highly stressed environments. We need to look at effects first and then work backwards.
- Identification of chemicals and sources that have toxic impacts. There are many unknowns; in particular, are we looking for the right chemicals?
- Toxic chemical types, loadings and sources are changing
- We don't know the natural level and the variability around them. What does the variability mean?
- Need to know what chemicals to look for (considering cost effectiveness)

2. What are the essential information and tools decision makers need to address these issues?

   Who are the users?

- State Agencies (DEP, Dept of Public Health, Fish & Game, Port Authority, etc.)

- Local agencies, such as zoning authorities
- Other Federal Agencies
- General Public

Information & Tools

- Need to know what are the sources of important contaminants and what organisms and/or systems are affected.
- Need to be advised on what attainable goals might be.
- What are the management options for different land uses and the link to multiple stressors.
- What are the remediation options

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- We don't understand interaction between chemicals and other stressors
- We don't know the sources, fates, effects and impacts
- Need to define the issues first and start at the effect level and work back towards the sources
- We don't know what the natural and perturbation states are
- We are lacking a monitoring program which is linked to the stressors produced by different land uses.
- Don't know and cannot predict the impacts of many modern contaminants.

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Define the important questions
- Develop research techniques to determine the health of the environment
- Design experiments to determine affects of multiple stressors on various components of the environment, trophic levels, scales (mesocosm?)
- Identify and utilize "high risk" areas (that have a high probability of having toxicity stressors) to develop information which can be used on a broader scale
- Define mitigation alternatives
- Research into basic affects of new toxicants being produced (e.g., pharmaceuticals)

2.3 Group II

NOTE - italics/strike thru's indicate additions/deletions made to session I results

1. What are the key issues related to this theme?

- Toxic contaminants act in concert with other stressors *in a variety of environments* ~~and only occur in highly stressed environments and we need to look at effects first and then work backwards.~~
- Identification of chemicals and sources that have toxic impacts. There are many unknowns - are we looking for the right one?
- Toxic chemical types, loadings and sources are changing.
- Don't know the natural level and the variability around them. What does the variability mean?
- Need to know what chemicals to look for (considering cost effectiveness).
- *Need to determine spatial extent and location of toxic contaminants and the proximity to sources.*
- *Extrapolating from measured quantities to cause and effects.*
- *Interpreting affects of multiple chemical exposures.*
- *Having appropriate models to screen for effects.*
  - *affects: endocrine disrupters, growth, reproduction and development.*
- *Incorporating toxic contaminants into population assessments of valued species and coastal management.*

2. What are the essential information and tools decision makers need to address these issues?

Who are the users?

- State Agencies (DEP, Dept. of Public Health, Fish & Game, Port Authority, etc.)
- Local agencies, such as zoning authorities
- Other Federal Agencies
- *Industry*
- General Public

What Information & Tools?

- Sources of important contaminants *(point and non-point source, historical vs. contemporary)* and what *and how* organisms and/or systems are affected.
- Advise on what attainable goals might be.
- Management options for different land uses and the link to multiple stressors.
- Remediation options.
- *Socioeconomic impacts of contaminants*.
- *Conveying impacts in terms of the value society places on the environment*.
- *Models, GIS, other visualization tools for use by managers to aid in decision making and communication.*

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Don't understand interaction *among chemicals themselves* and between chemicals and other stressors.

- Don't know the sources, fates, effects and impacts
- Need to define the issues first and start at the effects and work back towards the sources
- Don't know what the natural and perturbation states are
- Don't have a monitoring program which is linked to the stressors produced by different land uses.
- *Absence of approaches for addressing chronic impacts.*
- *Inability to model the long term affects of multiple low level compound exposure.*
- Don't know and cannot predict the impacts of many ~~modern~~ contaminants.
- *Translating scientific results into a form that is usable and understandable to the users.*

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Develop research techniques to determine the health of the environment
- Design experiments to determine affects of multiple stressors on various components of the environment, trophic levels, ... (mesocosm?)
- Identify and utilize "high risk" areas (that have a high probability of having toxicity stressors) and associated gradients to develop information which can be used on a broader scale
- *Link NCCOS to ORR and OCRM issues*
  - *effectiveness of management actions.*
  - *stewardship of NOAA resources.*
- Define mitigation alternatives
- ~~Research into basic affects of new toxicants being produced (e.g., pharmaceuticals)~~

2.4 Summary Groups I and II

1. What are the key issues related to this theme?

- Need to identify toxic impacts and the responsible chemicals and their sources.
- Toxic chemical types, loadings and sources are changing.
- Need to select chemicals for evaluation based on use, persistence and inherent toxicity.
- Don't know the natural range of biomarkers that can be responses to chemical contaminants.
- Need to determine spatial extent and location of toxic contaminants and proximity of source.
- Need to understand the relationship between measured contaminant concentrations and toxicity.
- Need to understand the affects of contaminant mixtures and their interaction with other stressors.
- Need to develop appropriate models to screen for toxicant affects (endocrine disrupters, growth, reproduction and development).
- Need to incorporate toxic contaminants into population models of valuable species and coastal management.

2. What are the essential information and tools decision makers need to address these issues?

Who are the users?

- State Agencies (DEP, Dept. of Public Health, Fish & Game, Port Authority, etc.); Local agencies, such as zoning authorities; Other Federal Agencies; Industry; and the General Public.

  What information & tools?

- Sources of important contaminants (point and non-point source, historical vs. contemporary) and what and how organisms and/or systems are affected.
- Advise on what attainable goals might be.
- Management options for different land uses and the link to multiple stressors.
- Remediation options.
- Socioeconomic impacts of contaminants.
- Ability to convey impacts in terms of the value society places on the environment.
- Models, GIS, other visualization tools for use by managers to aid in decision making and communication.

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Don't understand interaction among chemicals themselves and between chemicals and other stressors.
- Don't understand the relationship between measured contaminant concentrations and toxicity.
- Don't know what the natural and perturbation states are.
- Absence of approaches for addressing chronic impacts.
- Inability to model the long term affects of multiple low level compound exposure.
- Don't know and cannot predict the impacts of many modern contaminants.
- Inability to translate scientific results into a form that is usable and understandable to the users.

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Develop research techniques to determine the health of the environment and account for natural variability.
- Design experiments to determine affects of multiple stressors on various components of the environment, trophic levels, ... (mesocosm?).
- Identify and utilize "high risk" areas (that have a high probability of having toxicity stressors) and associated gradients to develop information which can be used on a broader scale
- Link NCCOS to ORR and OCRM issues.
  - effectiveness of management actions.
  - stewardship of NOAA resources.
- Define mitigation alternatives so that management scenarios are realistic.
- Evaluate the hazards of understudied, highly used and highly persistent contaminants (e.g., pharmaceuticals).

3. Eutrophication

Eutrophication can be traced to both natural and anthropogenic causes. Continued development within coastal watersheds by agricultural and urban interests is resulting in increasing degradation of coastal waters and habitats, and is linked to a number of fish kills and shifts in food webs. A holistic approach is needed to better understand the interaction of changing land use practices, natural climatological events, food web dynamics, etc. to better understand the causes and predict the ecological affects of nutrient overload to coastal waters.

Speaker:	Kevin Sellner (CSCOR)
Group I Chair:	Carolyn Currin (CCFHR)
Group II Chair:	Brian Eadie (GLERL)
Recorder:	Nancy Craig (CSCOR)

3.1 Speaker Summary

NCCOS is qualified to lead the NOAA Eutrophication Program because of its strong commitment to supporting research, and monitoring and documenting change in water quality, oxygen levels, productivity, habitat, and fish production through supported research and monitoring in its own laboratories and through an extramural research program.

- NCCOS needs to make a dedicated effort to develop an eutrophication program building on existing efforts such as the National Estuarine Eutrophication Survey and CENR Assessment.

- There are correlative relationships with nutrient loading and what are considered indicators of eutrophication in coastal waters, i.e.., hypoxia/anoxia

- Examples of coordinated efforts that examined/assessed impacts/interactions of nutrient loading on marine and freshwater systems are:

  - Gulf of Mexico Assessment- emphasizes the role of the watershed and land use practices on the GOM; 90% of the N & P inputs are nonpoint in GOM watershed

  - Great Lakes PO4 controls in Lake Erie, nutrient reduction coupled with zebra mussels altered nutrient interactions and cycling. While it has been claimed that PO4 controls have gone too far, there remains low D.O. problems inspite of PO4 controls. There is also the increased occurrence of Microcystis blooms in the Lakes

- While there are research and monitoring activities at the NCCOS Centers, NOAA needs to establish some kind of identity in the area of eutrophication

- Need to address socio-economic issues as a part of an integrated effort. That work can be done internal or externally, but we need to know the cost!

- NCCOS needs to develop a Strategic Plan for eutrophication that includes:

  - developing long term research plans
  - coordinating present and future research, monitoring and assessment activities, both intramural and extramural
  - conduct studies within the larger management context.

- Tuesday's workshop on Eutrophication included:

  - Key areas
  - Tools - eutrophication affects on structure and function of coastal ecosystems - how it can be measured
  - Impacts
  - Studies directed toward management goals - linking science and management

- There is a critical need for recognition that NCCOS/NOS IS THE AGENCY TO TURN TO AS THE LEAD FOR COASTAL EUTROPHICATION ISSUES

3.2 Group I

1. What are the key issues related to this theme?

- NOAA assessments of coastal ecosystems clearly illustrate numerous examples of degraded or declining ecosystem health
  Manifestations / Expressions include:
  - Food Web Effects (e.g. species shifts, food quality)
  - Anoxia / Hypoxia
  - HABs
  - Habitat Quality (Indices, Public perception)

2. What are the essential information and tools decision makers need to address these issues?

Information

- Identifying key controlling variables driving the system towards eutrophication
- Measuring and tracking (source identification) nutrient inputs & other key variables
- System information
  - Hydrodynamics, basin morphology, hydrology, land use
- Constituency

- Resource management network
- Perception of the issue

Tools

- Improved statistical protocols to ecosystem synthesize existing information (e.g. GIS land use, monitoring)
- Using National Estuarine Research Reserves System to study baseline sites
- Future selection criteria might include sites for compared or manipulated studies
- Improved models
- State of the art technology

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Lack of fundamental understanding of key processes
  - Biota response to changes in trophic status
  - Interactions of multiple stressors
- Lack of integrated long-term data sets to quantify natural variability
- Lack of early warning indicators

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Develop standardized protocols for State monitoring efforts
- Using NERRS and Sanctuaries as "labs"
- Focus research in a few critical areas
- Hypothesis-driven monitoring
- Process research to quantify cause-effect linkages
- Use a spectrum of scales (lab, microcosms, field) to control variables
- Integrate with other agencies
- Commit to long-term (> 10 years) programs at key sites to strengthen science management linkages

3.3 Group II

Definition

- Change in supply of inorganic and organic material with increase in biomass in excess over carrying capacity of system
- Term is generally ill defined

1. What are the key issues related to this theme?

- Causes
  - Relationship of land-use to result in/cause eutrophication, non-point sources
  - Is there evidence of eutrophication?
- Tools
  - Lack of predictive models linked to control measures
- Manifestations
  - Role of eutrophication in hypoxia/anoxia relative to hydrological processes, climate change or other factors
  - Food web effects
  - Role in HAB's, macrophyte distribution, water quality, light limitation
  - Public perception of eutrophication: water clarity, smells, and color

2. What are the essential information and tools decision makers need to address these issues?

- Is eutrophication occurring?
  - Direct and indirect indicators
  - Monitoring and historical data
  - Models for assessment and decision -making
  - Continuous time-series data /Trends
  - Loading rates
  - Incorporate spatial definitions
- What are effects and impacts, what are cumulative impacts among stressors
  - Understanding key controlling variables
  - Watershed information and linkages to coastal environment
  - Define carrying capacity of ecosystem- how much is too much?
  - Regional variations in site processes and characteristics
- Are management practices effective (reduce eutrophication), cost-effective
  - Requires pilot studies, testing, mesocosms

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Lack of consensus on definition of eutrophication
- Lack of understanding of processes
- Costs are high
  - Time series data collection
  - Remote monitoring
  - Appropriate spatial scales
- Lack of compatible data sets (consistent data collection)
- Lack of simple models and tools for decisions
- Labs and government take parochial approach

- Estuaries neglected relative to streams and watersheds relative to monitoring efforts (part technological problems)

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Need national program that insures QA and builds on existing information and partnerships with states. National program needs spokesman to bridge institutional gaps and represent issue to Congress
- Rapid Response teams to address causes of hypoxia/anoxia,
- Process oriented studies to define impacts of eutrophication

3.4 Summary Groups I and II

DEFINITION

Change in supply of inorganic and organic material with increase in biomass in excess over carrying capacity of system. The term is generally ill defined

1. What are the key issues related to this theme?

- NOAA assessments of coastal ecosystems clearly illustrate numerous examples of perceived degraded or declining ecosystem health with causes generally attributable to land use changes and other anthropogenic pressures
    - Examples of ecosystem degradation that may be attributable to eutrophication include:
        Food Web Effects (e.g. species shifts, food quality)
        Anoxia / Hypoxia
        HABs
        Water Quality (public perception)
        Habitat Degradation/Loss

2. What are the essential information and tools decision makers need to address these issues?

- Is eutrophication occurring?
    - Direct and indirect indicators
    - Monitoring and historical data
    - Models for assessment and decision - making
    - Continuous time-series data /Trends
    - State of the art technology
    - Loading rates
    - Improved statistical protocols to synthesize existing information (e.g. GIS, land use, monitoring)

- What are effects and impacts
  - Understanding key controlling variables
  - Watershed information and linkages to coastal environment
  - Define carrying capacity of ecosystem -how much is too much?
  - Regional variations in processes and characteristics
  - Are cumulative impacts important?
- Are management practices effective (do they reduce eutrophication, are they cost-effective)
  - Requires pilot studies, testing, mesocosms, and significant process level research
  - Using National Estuarine Research Reserves System to study baseline sites
  - Future selection criteria might include sites for compared or manipulated studies

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Lack of understanding of processes
- Lack of simple models and tools for decisions
- Lack of fundamental understanding of key processes
  - Biota response to changes in trophic status
  - Interactions of multiple stressors
- Lack of integrated and compatible long-term data sets to quantify natural variability
- Lack of early warning indicators
- Costs are high necessitating multi-agency partnerships
- Estuarine monitoring neglected relative to streams and watersheds efforts

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Need national program that insures QA and builds on existing information and partnerships with states.
- Spokesman to bridge institutional gaps and represent issues to Congress
- Rapid Response teams to address causes of hypoxia/anoxia
- Process oriented studies to define impacts of eutrophication
- Hypothesis-driven monitoring
- Using NERRS and Sanctuaries as "labs"
- Use a spectrum of scales (lab, macrocosm, field) to control variables
- Commit to long-term (> 10 years) programs at key sites to strengthen science-management linkages

4. Harmful Algal Blooms

The occurrence of harmful algal blooms is increasing in coastal areas world-wide. The causes of many of these blooms are largely unknown, but may be related to the growing use of coastal resources, changes in ocean climate, expanded distribution by ballast water exchange, or other natural and human-induced factors. The economic and ecological impact of these blooms must be determined, along with the development of knowledge to predict and mitigate their occurrences.

Speaker:	Pat Tester (CCFHR)
Group I Chair:	Danielle Luttenberg (CSCOR)
Group II Chair:	Fran Van Dolah (CCEHBR, Charleston)
Recorder:	Steve Morton (CCEHBR, Charleston)

4.1 Speaker Summary

Harmful Algal Blooms (HAB's)is the politically correct term for: Red Tides and Brown Tides that can include: cyanobacteria, *Aureococcus*, *Gymnodinium*, *Heterosigma*, *Alexandrium*, *Gambierdiscus*, *Pseudo-nitzschia*, *Dinophysis*, and *Pfiesteria*. The key issues with HAB's are: threats to human health; regional economic impacts; loss of consumer confidence in seafood safety; mass mortality of fin fish; reduction in environmental quality; marine mammal deaths; possible effects on non-commercial species, and possible water quality implications. HAB's scope includes all temporal and spatial scales: global, national, and regional, and long-standing and emerging issues. <u>What is presently being done</u>: 1993 National Plan for Marine Biotoxins & Harmful Algae; 1995 ECOHAB National Research Agenda; report on prevention, control and mitigation of HABs in coastal waters in 1997; and funded ECOHAB work in 1997. These publications and research efforts are important to decision makers in shellfish sanitation and public health and have addressed the following questions: what species were involved, what detection methods should be used, what toxin standards are appropriate, what areas were affected and when should these areas be reopened. Data collected and tools used for public health concerns have been newly developed: HAB species identification keys; ELISA, HPLC, mass spectometry, receptor binding assays, and molecular probes; and biomarkers for toxin exposure. <u>Who are the decision makers with HAB problems</u>: tourists, mariculture enterprises, and the public in general. <u>What is needed by these decision makers</u>: timely and accurate descriptions of what is happening, why it is happening, and what can be done about it. To provide this information, better monitoring techniques with remote sensing from all platforms, and descriptive models should be developed. Research should focus on: life cycle and cell cycle descriptions; the physiological ecology of nutrient sensitivity and photic requirements; triggering mechanisms for HABs; ecosystems effects including affects on grazers and food webs; and possible bacterial and viral control. <u>What to do next</u>: publicize results of research and reject moral egoism. We should not promise to fix the problem or predict blooms, though we should be able to identify conditions that are conducive to blooms (and provide now-cast and possibly forecast information based on physical-biological coupled models). We should de-emphasize products, provide seed money for high risk pilot studies. NCCOS cross-cutting teams are well positioned to do this.

4.2 Group I

1. What are the key issues related to this theme?

- Are HABs increasing in frequency, severity, distribution and type?
- What are the ecological effects and public health and socio-economic impacts of HABs?
- Can HABs be managed? Predicted/forecasted, prevented, controlled?

2. What are the essential information and tools decision makers need to address these issues?

- Better stats, more data on HAB species and composition, distribution, severity, impacts
- Prediction of HAB incidence
- Prediction of HAB impacts -health and socio-economic
- Characterization of potential and actual hazards during bloom events (i.e. short-term response measures, area closings, public advisories, etc.)
- Prevention (i.e., long-term management strategies, need for effective measures for prevention)

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Lack of long-term databases
- Lack of taxonomic understanding (current ID based on morphology not genetics)
- Characterize toxins: structure, function
- Characterize acute and chronic toxic affects
- Develop techniques for culturing of causative organisms for study and toxin source
- Lack of remote sensing application to track blooms
- Need biol. and phys. indicators and biomarkers

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Data mining, retrospective analysis
- Paleo work - examination of sediment cores
- Characterize toxins: structure, function
- Characterize acute and chronic toxic affects - quantification and mode of action, population level
- Monitoring bloom events
- Common performance-based methodology for research and monitoring
- Understanding environmental factors (physical, chemical, biological) controlling bloom initiation, maintenance, and termination
- Understanding factors for toxic expression
- Characterize toxins and develop standards
- Role of multiple factors of blooms

- Basic research on control and mitigation measures
- Research on public health and socio-economic impacts
- Affect of HABs, hypoxia on ecosystem integrity, food web, etc.
- Develop predictive models enabling issuance of HAB advisories to warn constituents of conditions when HABs are most likely to occur.

4.3 Summary Group I and II

1. What are the key issues related to this theme?

- HABs have ecological, public health and economic impacts.
- HABs appear to be increasing in frequency, distribution, severity, and type.
- Linkages between human activities and HABs are not well understood.
- Strategies to predict and manage HABs are currently limited.

2. What are the essential information and tools decision makers need to address these issues?

- Timely and accurate information to support management and mitigation of HAB impacts on public health, economics, and coastal resources.
- Management strategies for prevention, control and mitigation of blooms
- Forecasting capability for occurrence of HABs
- Public education and advisory tools
- Information on how and to what extent human activities contribute to HAB occurrence
- Information on how and to what extent HABs impact fishery resources, protected species, and coastal ecosystem health'

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Incomplete understanding of linkages between blooms and forcing factors
- Incomplete understanding of ecophysiology of organisms
- Inadequate tools for species identification and toxin detection
- Lack of toxin standards
- Lack of information on toxin structures and actions
- Incomplete characterization of acute and chronic affects of toxins
- Lack of adequate long-term databases on HAB incidence and relevant environmental factors

- Lack of adequate technologies for remote monitoring of HAB species, toxins and relevant environmental factors
- Lack of predictive models

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

Research

- Identify physical and biological factors controlling bloom initiation, growth, maintenance and termination
- Define affects of HABs on ecosystem structure/function, including trophic transfer of toxins, nutrient cycling
- Elucidate factors regulating toxicity in HAB species
- Determine toxin structure- and function
- Develop toxin standards
- Develop rapid, cost-effective probes, assays, and chemical analyses to detect HAB species and toxins
- Define acute and chronic affects of toxins in humans and coastal resources
- Paleoecological evaluation of changes in the abundance and distribution of HABs species over long time scales
- Develop remote detection technologies for HAB species, toxins, environmental variables
- Develop mitigation and control measures
- Identify and quantify roles of multiple stressors on bloom dynamics
- Isolate, culture, and make available cultures of HAB species

Modeling

- Develop models for predicting HABs that link physical, chemical and biological data to physical forcing.

Monitoring

- Establish common performance-based methodologies
- Employ remote sensing technologies in routine monitoring of environmental factors controlling bloom initiation, maintenance, termination.

Assessment

- Retrospective analysis of existing databases to test emerging hypotheses
- Provide accessible information on HABs to managers (e.g., GIS based mapping, programmatic brochures)
- Development of public outreach tools (information brochures, etc.)

5. Coastal and Marine Habitat Viability and Quantity

The viability and quantity of coastal habitat is being threatened by the ever-increasing development of coastal land. The capacity to predict the impacts of watershed change on habitat structure and function is essential for effective protection. The capacity to restore these habitats to conditions that support more natural systems, when environmental damage has been done, is based on a more complete understanding of their structure and function. To build these capacities and protect these important habitats (i.e. marsh, sea grass, intertidal flats, mud flats, water columns) it is essential that we understand the function of the systems relative to the support of living resources.

Speaker:	Jud Kenworthy (CCFHR)
Group I Chair:	Mark Fonseca (CCFHR)
Group II Chair:	Mark Monaco (CCMA)
Recorder:	Michelle Harmon (CCMA)

5.1 Speaker Summary

- Habitats are not single units, they are integrated and continuous.
- Habitats should include the parcels of water that is floating over other habitats.
- Habitats have a physical structure as well as an obscured structure.
- In the case of sargassum, there is a desire to "collect" the habitat or to physically remove the habitat.
- Multi-factors are affecting habitats including activities such as recreation, industry, and farming in addition to the many natural stressors.
- There is a need to develop research with statistical power in order to:
  (1) differentiate between natural and anthropogenic induced changes,
  (2) determine the habitats capacity for resilience,
  (3) to assist in the determination of what we can manipulate, and
  (4) to assist in the suitability and applicability of tools (tools need to adaptable).
- In some environments there is a need for 50-70 years of data in order to understand and illustrate changes or shifts.
- Remote sensing tools will be valuable to provide more data and information in the future.
- There is a lack in understanding the biotic interactions with habitats. For instance, stock sizes may be reliant on physical factors outside of our control.
- Key Issues :
  (1) There is a need for science and data in order to determine the capacity of habitats to maintain or recover, as well as the habitats capacity to support food webs,
  (2) additional data are needed in respect to species compositions and the affects of fragmentation and isolation. For instance, we know that systems have evolved that are physically fragmented but that are continuous,
  (3) all issues dealing with habitats are a question of scale. There is a lack of data on the

cumulative impacts of small disturbances,
(4) additional data are needed on top down and bottom up controls,
(5) there is a need for additional guidance on restoration; is it necessary and/or is it possible to regain the original structure and function?,
(6) in order to create and apply existing models (Optical Water Quality Modeling, Landscape Modeling and Restoration, and Habitat Equivalency Analysis) there is need to better understand environmental variables,

- Data collecting efforts should be mindful of the following:
  (1) scale as it relates to the issue,
  (2) hypothesis testing,
  (3) spatial articulation, and
  (4) balance between long and short term data sets.

5.2 Group I

1. What are the key issues related to this theme?

- Understanding the complexities and thresholds of natural and man-induced changes (including injuries, aquaculture)
- Characterization - function of scale (temporal and spatial)
  - definition
  - quality
  - patterns
  - use
  - variability
  - linkages (including water column)
  - be sensitive to biogeographical differences
  - include new and understudied habitats
- Integrate environmental factors for application (interpretive tools)
  - for scientists
  - for managers

Original list of key issues:

- habitat variability
- aquaculture effects
- linking uplands and wetlands via water column
- develop interpretive tools
- study new habitats
- historical memory of habitat variability
- scope of impact

- rethink sample protocols
- geographic context of studies
- thresholds and non-linearity
- scale dependency
- definition of habitat
- habitat quality
- restoration
- patterns and spatial extent
- use
- linkages
- species diversity changes with habitat changes
- translating data for management
- predictive capabilities

2. What are the essential information and tools decision makers need to address these issues?

- Success criteria
  - initiating action
  - what constitutes effective remediation
- Protocols for locating and choosing sites
- Protocols for choosing alternatives to restoration, whether the project should be permitted
- Set goals for regional characteristics of habitats that includes variability (reference site issues)
- Time series data of key processes
  - area occupied by habitat
  - services provided by the habitat
- Index of health and viability
- Habitat distribution, abundance, and change analyses
- GIS training and capabilities
- Characterization of function and values
- Predict consequences of change
  - early warning signs
  - methods to monitor and assess trends
- National GIS database of restoration projects
- Transferability of data among geographic regions
- Identify socioeconomic impacts of restoration vs. conservation vs. protection
- Assessment of habitat quality (births and deaths) and linkages (immigration and emigration)

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Resource allocation: capital investment and staffing
- Time scale mismatch between information need by managers and delivery by scientist
- Lack of communication between NCCOS, states, universities

- Lack of cross cutting between disciplines
- Intra and inter agency communication tools and delivery systems
- Causality and attribution e.g. linking chemicals with toxicity
- Incomplete National representation
- Regional nature of studies - try to find ways to cut across regions
- Managers not involved in scientific process
- Technological inability for state and local managers to utilize research findings
- Lots of little projects with no integration

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Require and encourage and REWARD outreach/information transfer:
  - to be interdisciplinary
  - to meet time scale discrepancy
  - to overcome delivery system.....organizational information to include contact names by subject, research profiles, and pictures of individuals
- Policy to get data out as soon as you are willing to back it
- Clarify NCCOS policy of data availability
- Clarify NCCOS policy on press contact
- Establish collaborative efforts across centers
- Target new/under studied areas for basic research e.g. San Francisco toxics, west Florida deep water sea grass
- Assessment of what happens when pollution is turn off
- When spills are over - lack of data on various chemicals and their toxicological significance
- Develop predictive models to:
  - identify habitat characteristics for long term time series monitoring
  - direct hypothesis based research to focus on management needs
- Long term monitoring (e.g. use NERRS sites)
- Better quantification of habitat loss
- Retrospective analyses of long term databases

5.3 Group II

1. What are the key issues related to this theme?

- There is a need to characterize the biological, physical, and chemical characteristics of habitats as a basis for evaluation over time.
  - What are the habitats
  - Where are the habitats
  - How much is there.

  - Appropriate scale of action
  - What is the spatial and temporal variability in habitats.
- We do not know the thresholds from anthropogenic and/or natural disturbances that cause changes in habitat function.
- There are recognized, but under studied habitats that require research as to their contribution ecosystem function.
- Habitat requirements (linkages among habitats) are unknown for many species/life stages.
- Restoration
  - There is difficulty in defining what anthropogenic disturbance vs. natural habitat conditions mean relative to ecosystem function and defining successful restoration.
  - Due to the complexities of restoration societal and science goals must be evaluated.
- There is a need for better measures of cumulative impacts of multiple stressors.
- We do not have a good understanding of the impacts of anthropogenic activities (e.g. land use) on various habitats (cause and effect relationships)

2. What are the essential information and tools decision makers need to address these issues?

- Desktop information systems need to be developed for habitat assessments.
- More and better spatial data on habitat quality and quantity needs to be collected at appropriate spatial and temporal scales
- GIS models that integrate biology and physical variables that affect habitat need to be developed.
- Remediation and or management options e.g. risk analysis need to be provided including success criteria for restoration and/or remediation projects.
- Protocols for locating, choosing sites, and alternatives to restoration.
- Development of habitat health and viability
  - early warning signs
  - methods to monitor status and trends
- National database of restoration projects.
- Synthesis of habitat functions and values.
- Adequate sampling that characterizes habitat variables over appropriate spatial and temporal time scales should be conducted to enable time series analyses.
- What are the best management practices to maintain and preserve habitats
- Managers need tools to model and predict the affects on habitats under various impact scenarios.

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Time scale mismatch between information need by managers and delivery by scientist
- Lack of communication between NCCOS, states, universities
- Lack of cross cutting between disciplines
- Intra and inter agency communication tools and delivery systems
- Causality and attribution e.g. linking chemicals with toxicity
- Incomplete National representation

- Regional nature of studies - try to find ways to cut across regions
- Managers not involved in scientific process
- Technological inability for state and local managers to utilize research findings
- Lots of little projects with no integration
- Habitat affinities are difficult to define.
- Lack of pristine or reference sites.
- Political influence on the location of Reserves and Sanctuaries.
- Difficulties in merging multiple datasets due to inconsistencies in sampling and analysis.
- The inability to train and maintain information/technical specialists
- Need to develop and/or refine tools to detect responses of habitat degradation.
- Not adequate follow-up and implementation of workshop, research, monitoring, and assessment activities.
- We don't have a comprehensive accounting of the early life histories of species in coastal and marine ecosystems.

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- NCCOS should conduct long term monitoring and research to collect the required data to understand natural variability and to enhance our power to detect change via:
    - incorporating hypothesis testing
    - use of appropriate spatial and temporal scales
    - sensitive indicators
- Need to design experiments that address the interactions of multiple stressors at acute, chronic and sub lethal levels.
- Need to conduct research to define utilization of habitats by species' life stages.
- Conduct research to determine the cumulative impacts with great accuracy.
- Conduct research to determine how climate change affects habitats.
- NCCOS must provide fiscal and human resources to maintain long-term program continuity.
- Analyze the early life histories of fishes in major ecosystems
- NCCOS should develop consistent abiotic and biotic sampling protocols.
- NCCOS should capitalize on the diversity of expertise to address habitat related problems by providing appropriate incentives.
- NCCOS should work with Sanctuaries and Reserves to provide a scientific basis for reference site selection (e.g. pristine site selection).
- Require and encourage and REWARD outreach/information transfer
    - to be interdisciplinary
    - to meet time scale discrepancy
    - to overcome delivery system.....organizational information to include contact names by subject, research profiles, and pictures of individuals
- Policy to get data out as soon as you are willing to back it
    - clarify NCCOS policy of data availability
    - clarify NCCOS policy on media contact

- Establish collaborative efforts across centers
- Target new/under studied areas for basic research e.g. San Francisco toxics, west Florida deep water sea grass
- Assessment of what happens when pollution is turned off
- When spills are over - lack of data on various chemicals and their toxicological significance
- Develop predictive models to identify:
  - habitat characteristics for long term time series monitoring
  - direct hypothesis based research
  - to focus on management needs
- Better quantification of habitat loss
- Retrospective analyses of long term databases

5.4 Summary Groups I and II

1. What are the key issues related to this theme?

- There is a need to characterize the biological, physical, and chemical characteristics of habitats as a basis for evaluation over time.
  What are the habitats?
  Where are the habitats?
  How much is there?
  Appropriate scale of action
  What is the spatial and temporal variability in habitats?
- Restoration
  - There is difficulty in defining what anthropogenic disturbance vs. natural habitat conditions mean relative to ecosystem function and defining successful restoration.
  - Due to the complexities of restoration societal and science goals must be evaluated.

2. What are the essential information and tools decision makers need to address these issues?

- GIS models that integrate biology and physical variables that affect habitat need to be developed.
- Adequate sampling that characterizes habitat variables over appropriate spatial and temporal time scales should be conducted to enable time series analyses.
- Managers need tools to model and predict the affects on habitats under various impact scenarios.

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- The variability of the natural environments is inherently large. NCCOS must address this issue.

- Habitat affinities are difficult to define.
- Lack of pristine or reference sites.
- Political influence on the location of Reserves and Sanctuaries.
- Difficulties in merging multiple datasets due to inconsistencies in sampling and analysis.
- The inability to train and maintain information/technical specialists
- Need to develop and/or refine tools to detect responses of habitat degradation.
- Not adequate follow-up and implementation of workshop, research, monitoring, and assessment activities.
- We don't have a comprehensive accounting of the early life histories of species in coastal and marine ecosystems.

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- NCCOS should conduct long term monitoring and research to collect the required data to understand natural variability and to enhance our power to detect change via:
  - incorporating hypothesis testing
  - use of appropriate spatial and temporal scales
  - sensitive indicators
- Need to design experiments that address the interactions of multiple stressors at acute, chronic and sub lethal levels.
- Need to conduct research to define utilization of habitats by species' life stages.
- Conduct research to determine the cumulative impacts with great accuracy,
- Conduct research to determine how climate change affects habitats.
- NCCOS must provide fiscal and human resources to maintain long-term program continuity.
- Analyze the early life histories of fishes in major ecosystems
- NCCOS should develop consistent abiotic and biotic sampling protocols.
- NCCOS should capitalize on the diversity of expertise to address habitat related problems by providing appropriate incentives.
- NCCOS should work with Sanctuaries and Reserves to provide a scientific basis for reference site selection (e.g. pristine site selection).

6. Understanding the Affects of Oceanographic Change on Coastal Ecosystems

A major issue in managing and conserving living marine resources is understanding the range of environmental factors that control the natural variability of the abundance of these resources and the ecosystems upon which they depend. This knowledge, needed in both the short (annual) and the long term (decadal) and on meso and macro scales, allows the causes of change in population abundance and food web structure to be attributed to either natural events or human activities. Understanding fundamental processes related to regime shifts, recruitment, and establishment of refugia and other management approaches is aided by knowing how the natural system influences coastal ecosystems.

Speaker:	Beth Turner (CSCOR)
Group I Chair:	Jon Hare (CCFHR)
Group II Chair:	Larry Settle (CCFHR)
Recorder:	Jeff Govoni (CCFHR)

6.1 Speaker Summary

- Oceanographic changes that can affect coastal ecosystems
  - Climate change
  - Regime Shifts
  - Episodic atmospheric-Oceanic Events (ENSO, NAO)
  - Anthropogenic Influences
  - Reversible vs. Irreversible

- Understanding affects of oceanographic change
  - Understand ecosystems processes
    - Functioning
    - Linkages (phys/biol, food web)
    - Scales of variability (spatial and temporal, physical and biological)
  - Define and describe coastal habitat and utilization
    - Definition of physical/biological habitat (substrate, hydrography, life cycles)
    - Descriptions of dynamics (production cycles, vital rates, hydrodynamics)

- What can NCCOS offer to decision-makers?
  - Predictive capability from physical-biological models
    - forecast near-future trends from current data
    - forecast potential results of managements decisions (multi-species management)

- Characterize key forcing functions and species
    - focus management on appropriate areas

- Identify indicators of oceanographic change
    - allow management to be proactive rather than reactive

- Approaches to Understanding

    - Field Studies (Ships, Moorings, Satellites)
        - Focused process studies
        - 3-D mesoscale surveys
        - Long-term monitoring

    - Retrospective Data Analysis and Paleoceanography
        - Environmental variables
        - Plankton time series
        - Fisheries time series

    - Coupled Physical-Biological Modeling
        - Wind and buoyancy-driven circulation, stratification, and upwelling
        - Cross-shelf and cross-front transport
        - Boundary current position, meanders, and eddies
        - Langmuir cells
        - Internal waves
        - Animal population dynamics
        - Plankton distribution and transport

    - Application of New Technologies
        - Population genetics
        - Microgrowth analysis
        - Acoustic sampling (ADCP)
        - Optical sampling (Video camera)
        - Remote sensing
        - GIS mapping

- Future directions for NCCOS studies

    - Numerical modeling of circulation & hydrography coupling with biological models
    - Multispecies modeling
    - Data assimilation
    - Appropriate scales for monitoring and assessment

- Cross-regional issues

    - Comparisons of ecosystems
    - Influence of extreme events
    - Integration across spatial and temporal scales

- Specific Geographic Foci?

    - Gulf of Mexico
        - Seasonal hypoxia/anoxia
        - Water column habitat degradation
        - Affects on larval fish

    - Bering Sea
        - Coccolithophore bloom
        - Oceanographic causes
        - Ecosystem affects

    - S. Florida Reefs
        - Changes in species assemblages
        - Refugia

6.2 Group I

1. What are the key issues related to this theme?

- Determine critical scales of oceanographic and climatic variation that effect the structure and function of coastal ecosystems using coupled physical, chemical, and biological approaches
- Define and describe water column, pelagic habitat use in the coastal ocean
- Determine the resilience of species, communities, and ecosystems to oceanic/climatic change
- Determine how oceanic change affects cross-margin interactions (e.g., watershed, estuarine, and coastal ocean
- Complete life history information for most aquatic organisms

2. What are the essential information and tools decision makers need to address these issues?

- Determining how ocean variability affects management strategies, e.g., refugia
- Interpretation and packaging of data
- Conceptual and predictive models
- Long term monitoring
- Retrospective analysis of data
- Socioeconomic evaluation of oceanographic changes

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Adequate time series of relevant physical, chemical and biological data at the appropriate scales do not exist
- Mechanistic links between lower and higher trophic levels are poorly understood
- Ineffective information transfer from scientists to managers, and from managers to scientists
- Availability and access to new and upgraded technologies across NCCOS Centers
- Required taxonomy and life history studies receive inadequate support
- Inadequate synoptic spatial and temporal data

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Use remote sensing platforms for research, monitoring, and assessment of oceanographic conditions at various spatial scales with continued algorithm development and validation
- Data assimilation and synthesis to educate decision makers and the public
- Develop multi-disciplinary teams (e.g., physicists, chemists, biologists, and climatologists) to assess problems created by oceanographic change
- Improve long-range forecasting of oceanographic conditions through the use of ocean monitoring data
- Design and implement long-term, coupled (biological, chemical, and physical) monitoring of the coastal environment
- Implement focused process oriented studies and build conceptual and predictive models that link across spatial and temporal scales
- Identify and use key indicators to assess the affect of oceanographic variability on ecosystem structure and function
- Support paleooceanographic and climatological studies of ocean/climate variation
- Develop novel techniques for species identification and chemical characterization oceanic change

6.3 Group II

1. What are the key issues related to this theme?

- Determine critical scales of oceanographic and climatic variation that affects the structure and function of coastal ecosystems using coupled physical, chemical, and biological approaches
- Define and describe water column habitat use in the coastal ocean
- Determine the resilience and ’adaptive’ potential of species, communities, and ecosystems to oceanic/climatic change

- Determine how oceanic change affects cross-margin interactions (e.g., watershed, estuarine, and coastal ocean
- Life history information is incomplete for most aquatic organisms

2. What are the essential information and tools decision makers need to address these issues?

- Determining how ocean variability affects management strategies, e.g., refugia
- Interpretation and packaging of data
- Conceptual and predictive models
- Long term monitoring
- Retrospective analysis of data
- Socio-economic evaluation of oceanographic changes

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Adequate time series of relevant physical, chemical and biological data at the appropriate scales do not exist
- Mechanistic links between lower and higher trophic levels are poorly understood
- Ineffective information transfer from scientists to managers, and from managers to scientists
- Availability and access to new and upgraded technologies across NCCOS Centers
- Required taxonomy and life history studies receive inadequate support
- Inadequate synoptic spatial and temporal data

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Use remote sensing platforms for research, monitoring, and assessment of oceanographic conditions at various spatial scales with continued algorithm development and validation
- Data assimilation and synthesis to educate decision makers and the public
- Develop multi-disciplinary teams (e.g., physicists, chemists, biologists, and climatologists) to assess problems created by oceanographic change
- Improve long-range forecasting of oceanographic conditions through the use of ocean monitoring data
- Design and implement long-term, coupled (biological, chemical, and physical) monitoring of the coastal environment
- Implement focused process oriented studies and build conceptual and predictive models that link across spatial and temporal scales
- Identify and use key indicators to assess the affect of oceanographic variability on ecosystem structure and function
- Support paleooceanographic and climatological studies of ocean/climate variation
- Develop novel techniques for species identification and chemical characterization

6.4 Summary Groups I and II

1. What are the key issues related to this theme?

- Oceanographic and Climatic Variation Affects Coastal Ecosystems Over a Variety of Scales - microscale turbulence to ENSO

- A Variety of Habitats Are Affected by Oceanographic and Climatic Change - fronts, gyres

- Species Interact with Oceanographic and Climatic Change - Biology

- Populations, Species, Habitats, & Ecosystems Have Some Capacity to Stand Up To (resilience) or Change with ('adapt') Oceanographic and Climatic Change

2. What are the essential information and tools decision makers need to address these issues?

- How does Oceanographic and Climatic Variability Affect Management Strategies - marine reserves

- Conceptual and Predictive Models

- Long-Term Monitoring/Retrospective Analysis of Data/Data Mining-Putting Oceanographic and Climatic Change into Context

- Interpretation and Packaging of Data for Users

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Inadequate time series of physical/biological/chemical data at appropriate scales

- Mechanistic links between lower and higher trophic levels are poorly understood - modeling and empirical problem

- Basic biological information (taxonomy, life history) is still required

- Information transfer between NCCOS and Users & within NCCOS

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Develop multi disciplinary teams to assess the affect of oceanographic and climatic change on coastal ecosystems

- Implement process oriented studies and build conceptual and predictive models that link across scales

- Identify and use key indicators to assess the affect of oceanographic and climatic variability on ecosystem structure and function

- Support long-term monitoring of the coastal environment - key indicators

- Support paleooceanographic and climatological studies of ocean/climate variation

- Data assimilation and synthesis - within NCCOS to support science and for outside NCCOS to educate decision makers (Congress to the person on the street)

- Develop and use remote sensing to study oceanographic change - large spatial scale, decent resolution for the coastal ocean, good sampling frequency

7. Coastal Forecasting, Natural Hazards, and Water Resources

NOAA must build and refine its capability to forecast water levels, erosion, storm surge, currents, and wave heights not only to support maritime services, but also to protect the general public. Knowledge of these physical processes is needed to improve the predictive capacity for protecting lives and property from natural hazards, and to more efficiently allocate water resources.

Speaker:	Curt Mason (CSCOR)
Group I Chair:	Tom Croley (GLERL)
Group II Chair:	Dave Reid (GLERL)
Recorder:	Nathalie Valette-Silver (CCMA)

7.1 Speaker Summary

1. Coastal Forecast Systems

Goals: Provide National capability to measure, understand and forecast coastal environmental phenomena impacting economies, public safety and environmental management.

Design: High resolution, local observation/forecast systems of environmental conditions. Initiated in 1993; FY 2000 Budget Initiative $1.5M through DoC.

Components:

- Observations: In-situ; ground/sea-based remote; satellite remote
- Modeling: Regional coastal ocean forecast; Near-shore/local hi-resolution
- Dissemination: Weather Forecast Offices; coastwatch; internet; NOS Ports; Private sector.

Ongoing efforts:

- Regional Scale: East Coast COFS; Pacific Coast Forecast systems; Gulf of Mexico and shelf models.
- Local Scale: Great Lakes forecast system; Great Lakes Advanced Hydrologic Prediction system; Bay and harbor nowcast/forecast systems will be transitioned to PORTS (Chesapeake Bay, Port of New York and New Jersey; Galveston Bay; Tampa Bay, San Francisco Bay.

Who are the users?

Maritime Commerce; Commercial/recreation fishing & boating; natural resource managers; emergency managers & Hazmat; fed, state, local governments.

What do they need?

- Near real time nowcasts and forecasts (ocean state; atmospheric conditions; hazards and extreme state conditions).
- Data for retrospective analyses & for planning and design.
- Visual displays of real time conditions and forecasts.

Impediments that NCCOS could address:

- Fundamental Problem: Incomplete understanding of interaction between ocean, atmosphere, and ecosystems,
- Lack of sufficient spatial/temporal resolution in existing models,
- Inability to properly couple physical and biochemical models.
- Lack of accurate, cost-effective observational technologies,
- Gap between R&D and operational communities.

CFS R&D needs

- Improve bay open-boundary conditions from regional model
- Accurate over-bay wind fields
- Increased spatial resolution at key areas
- Improve 4D data assimilation procedures
- Improve ensemble averaging techniques
- Better methods of defining uncertainty similar to hurricane probability
- Observation needs: upgrade minimal requirements; define optimal requirements
- Operational evaluation: model sensitivity to lateral boundary conditions & forcing that introduce error in forecast; assess model predictability with observations

NCCOS Contributions to CFS

- Support GLFS development/transition in FY 2000
- Support needs of NOS partners for CFS R&D
- Ensure NOAA CFS need coordinated with NOPP
- Lead/coordinate NOAA-wide budget initiatives
- Stimulate coupling of physical and biological modeling

2. NCCOS and Natural Hazards: Exploring opportunities for growth

Problem:

- Costs of natural disasters ~$50B/y and increasing
- Impact on ecosystems unaccounted for.
- NOAA emphasis on forecast and warnings (winds, surge, floods, waves).

- In NOAA, little attention of impacts on coastal ecosystems and resources.

What is NCCOS doing now? NCCOS hazard related science

- GLFS development
- Episodic impacts
- Impacts on water column and other habitats: Sabre, Sea grass, Lake Champlain
- NCCOS coordination efforts: NOAA CFS; NOAA/DOC NDR; ISSE.

What else could be done? Opportunities for new and expanded NCCOS partnerships in natural hazards impacts

- C&GS: Shoreline mapping/photogrametry
  - Analytical component lacking
  - USGS, CoE use data for science
  - Expand NCCOS/C&GS efforts
- CSDL: Apply CFS products to ecosystem impacts
- Hazmat/CCMA: Expanded partnership on storm-induced resuspension of polluted sediments
- CSC: Risk Assessment & socio-economical impacts; relying on other agencies for science; little emphasis on ecosystems.
- CSCOR: Minimal effort. Could (should?) redirect/expand sponsored R&D to hazard issues
- GLERL: Ability to build on suite of hazard-related capabilities
- ISSE: Revitalize NOAA contribution to hazard impacts.

Role of breakout groups:

Lay the foundation for NCCOS strategy to quantify & mitigate natural hazard impact on coastal ecosystems and habitats.

7.2 Group I

1. What are the key issues related to this theme?

- Lack of understanding of the value of probabilistic forecasts of impacts important to decision makers

- Poor understanding of how to use probabilistic hydrological forecasts by managers and decision makers

- Lack of use of probabilistic format in making forecasts of coastal processes, natural hazards, and water resources.

- Lack of use of probabilistic climate outlooks in making forecasts of coastal processes, natural hazards, and water resources
- The understanding of the ocean and atmosphere interactions in the description of circulation physics is missing
- Computer capability limitations for forecasters, need for access to faster parallel processing
- Need higher temporal resolution in modeling for short-term extreme events
- Forecasts are presently oriented towards saving lives and minimizing property damages and NOT to protect the natural environment
- Need to link forecasts to natural resource managers' needs
- Need to know what the resource impacts in commercial applications are for forecasts
- Need to use forecasts to prepare evaluation or assessment teams to understand impacts
- Poor understanding of user needs, particularly for small spatial and temporal scales
- Need more directed forecasts (e.g., pesticide application on hog farms, chicken farms, golf courses)
- Need to include land use in models for assessing pulse events
- Need more extreme data for model definition
- Poor to non-existent linkage between physical and biological models
- Lack of short-term ice forecasting and associated sediment transport
- Near real time nowcasts and forecasts (ocean state; atmospheric conditions; hazards and extreme state conditions).
- Data for retrospective analyses & for planning and design.
- Visual displays of real time conditions and forecasts.

2. What are the essential information and tools decision makers need to address these issues?

- Method to match multiple-agency, multiple-area, multiple-period climate outlooks probabilistically

- Risk-based decision making that uses probabilistic forecasts

- Coastal managers need sight-specific information (1" = 200' and 1" = 400' scales) on flood and surge heights and duration and storm event wind speed to properly sight and permit coastal development, develop appropriate storm-resistant building standards, and design, review, and permit public facilities such as harbors, roads, and bridges, and coastal recreation facilities

- Education of users to make full use of forecasts and models

- Need higher-capacity computers for resolving boundary condition issues and finer resolution computations

- Inventory of NCCOS computing capacity

- Need a break-through in ways to deal with open boundary conditions

- Equipment in place to measure baseline conditions

- Need monitoring, modeling, and assessment to understand impact of extreme events

- Need constituent input exercises (need to know what they want)

- Need integration of weather forecasts with process models where relevant

- Improve bay open-boundary conditions from regional model

- Accurate over-bay wind fields

- Increased spatial resolution at key areas

- Improve 4D data assimilation procedures

- Improve ensemble averaging techniques

- Better methods of defining uncertainty similar to hurricane probability

- Observation needs: upgrade minimal requirements; define optimal requirements

- Operational evaluation: model sensitivity to lateral boundary conditions & forcing that introduce error in forecast; assess model predictability with observations

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- No priority setting exists in the use of resources

- Complexity of matching climate outlooks are excessive for managers

- Ignorance of lay decision makers in using risk-based methods

- Ignorance of what others are doing and what is available in NCCOS, NOS, and NOAA; there is too little transfer of information within NOAA

- No data on impacts of extreme events on coastal ecosystems

- Fundamental Problem: Incomplete understanding of interaction between ocean, atmosphere, and ecosystems,

- Lack of sufficient spatial/temporal resolution in existing models,

- Inability to properly couple physical and biochemical models.

- Lack of accurate, cost-effective observational technologies,

- Gap between R&D and operational communities.

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Inventory of computing resources in NCCOS and possibility of sharing

- Assessment of user needs

- Better planning and coordination between disciplines (physical, biological, modelers, data gatherers)

- Develop representative risk-based decision-making models for select but broad management applications

- Research on matching climate forecasts in forecasts of coastal processes, natural hazards, and water resources and development of methodology in easy-to-use and understand interfaces for general use by managers

- Increase interactions within NCCOS, NOS, NOAA, and constituents

- Forecast cause and effect of episodic and extreme events on biological systems, including habitat, environmental changes, shell fisheries and fishery resources, commercial and recreational

- Include assessment of impact of extreme episodic events on coastal ecosystems

- Stimulate coupling of physical and biological modeling

7.3 Group II

1. What are the key issues related to this theme?

- Coastal populations and shoreline development are increasing and therefore the severity of impacts and costs associated with extreme events are increasing.

  - coastal shoreline inundation during severe storm events is a threat to life and property, but is poorly predicted.

  - we suffer an inability to make accurate and timely forecasts of coastal conditions

- Coastal population explosion is leading to depletion of water resources and land subsidence.

- The huge size of modern tankers and cargo ships has made maritime accidents and hazardous spills more likely, especially in restricted or depth-limited water bodies as found in many coastal areas.

- Increased human population and use of coastal areas poses an increasing threat to coastal ecosystems.

- Affects of extreme events on economically valuable resources are not well enough understood to allow mitigation of economic losses - forecasts are presently focused on savings lives and property, NOT protecting the natural environment.

- There is inadequate coastal environmental information to support search and rescue operations by the Coast Guard and Navy.

- Physical-ecological coupling is not well defined and inadequately understood.

- Improvements to the cost-effectiveness of navigation and transport of cargoes are limited by insufficient coastal environmental information.

- Long-term forecasts of coastal processes, natural hazards, and water resources are often inexpressible as a simple deterministic outlook (which is more appropriate for short-term or high-frequency forecasts).

  - the value of probabilistic forecasts is poorly understood by decision makers;

  - many managers and decision makers do not know how to use probabilistic forecasts;

  - the probabilistic format is not used often enough in making forecasts;

  - (probabilistic) climate outlooks are largely unused in making forecasts.

- Insufficient temporal resolution in models to forecast extreme events.

- Present forecasts are not always relevant to the needs of natural resource managers.

- Land-use is not always included in models for assessing pulse events.

- Data collected during extreme events are not sufficient for model definition.

- Lack of short-term ice forecasting and associated sediment transport.

2. What are the essential information and tools decision makers need to address these issues?

- Accurate high resolution nowcasts and forecasts are needed for water levels, ocean state, storm surges, atmospheric conditions, currents, temperature structure, salinity fields, wind and waves, as well as forecast uncertainties;

  - need more directed forecasts (e.g., pesticide application on hog farms, chicken farms, golf courses)

  - data for retrospective analyses (hind-casts) and for planning and design;

  - need to develop improved 4D data assimilation procedures.

- User-friendly visualization tools for dissemination/display of environmental and forecast information.

- Probabilistic risk and cost assessments of coastal hazards.

- Accurate projections of subsidence related to water withdrawals. Advanced high resolution hydrologic models on a regional basis.

- Detailed understanding of the relationship between the physical environment and the biological/ecological environment - such as integration of weather forecasts with ecosystem process models where relevant.

- Improved understanding and more accurate prediction of coastal currents and wind fields.

- Need to match multiple-agency, multiple-area, multiple-period climate outlooks in making long-term forecasts of water resources.

- Inventory of NCCOS computing capacity.

- Need improved methods for dealing with and incorporating boundary conditions.

- Need to know baseline conditions to assess impacts of extreme events.

- Need constituent input - what do they need and want?

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?
4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

(**) represents impediments that can be addressed by NCCOS

- Lack of real-time over-water data and observation networks for key forcing, such as wind, waves, and temperature fields.**

- Incomplete understanding of the coupling between ecosystem components, physical and ecological processes, and ecosystem responses,**

    - lack of research to understand complex physical-biological coupling;

    - poor to non- existent linkages between physical and biological models;

    - lack of data and assessments covering the impacts of episodic and extreme storm events on coastal ecosystems.

- Lack of methodologies for valuation of the natural environment and the indirect costs associated with natural hazards.**

- Lack of very high resolution digital terrain data for GIS systems.

- Lack of aquifer recharge models.

- Lack of proven methodologies in forecast models for**

  - data assimilation
  - ensemble averaging
  - estimating forecast uncertainties

- Differences in measurement capabilities for physical and ecological parameters**Resource managers need education and training to make full use of forecasts and models:**

  - complexity of matching climate outlooks is excessive for managers;

  - many decision makers have no understanding of risk-based methods;

  - lack of simple risk-based decision models for use as training tools.

- Lack of intra-NOAA (cross-LO) and intra-NOS communications and coordination about science needs, existing capabilities, what is available - who is working on what; communications gap between R&D and Operations community; inventory of computing resources available to NCCOS.**

7.4 Summary Groups I and II

1. What are the key issues related to this theme?

- Coastal populations, shoreline development and use of coastal resources are increasing

  - threats to life and property
  - risks to ecosystems
  - depletion of natural resources
  - inadequate system understanding

LIMITS ABILITY TO MINIMIZE LOSSES AND MAXIMIZE SUSTAINABILITY!!

2. What are the essential information and tools decision makers need to address these issues?

- Accurate high resolution nowcasts and forecasts
- High resolution data and observational capabilities
- Understanding of physical-ecological coupling
- More use of probabilistic methodologies
- Orientation to user needs

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?
4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

Questions 3/4 were handled at the same time

- Lack of real-time measurement capabilities
- Poor data assimilation & forecasting methodologies
- Matching climatic outlooks in derivative forecasts
- Abysmal understanding of complex couplings between system components forcing and response; physical/biological, etc.
- Links between extreme events and ecosystem response
- Very poor methodologies for valuation of coastal ecosystems and calculation of ecosystem costs (losses) associated with severe events.
- Communications
  - with users
  - within NOAA
- Most resource managers and decision-makers lack of necessary skills to use sophisticated forecasts properly

8. Climate Variability and Change

Global climate change complicates our efforts to understand short term human-related impacts on coastal resources. Alterations in warming and cooling cycles, for example, can have significant impacts on the distribution and abundance of living marine resources and the food webs that supports them. Changes in precipitation patterns can influence inflow of essential fresh water to estuarine and Great Lakes systems, while changes in the frequency and intensity of storms may affect protection of life and property, as well as fish recruitment processes. Although much has been done to predict changes in climate, we now need to focus our efforts on better understanding the ecological impacts of climate change.

Speaker:	Rick Stumpf (CCMA)
Group I Chair:	Frank Quinn (GLERL)
Group II Chair:	Beth Turner (CSCOR)
Recorder:	Roger Griffis (NOAA HQ)

8.1 Speaker Summary

Changes in climate have been documented. These changes have an impact on coastal habitat. It is important to understand the ecological impacts of climate changes and variability. Need to understand and predict impacts of climate variability and natural disasters using coastal forecasting capabilities with real-time monitoring and water resource forecasting systems.

What are the Key issues?

- At the global scale: global warming and sea level rise
- At the national scale: sea level rise, impact of global warming, expected variability (ENSO), other variabilities.
- At the regional scale: temperature extremes, flood and drought.

- Increase in CO_2 in the atmosphere has been well documented since the 1800's and extrapolation of the curve for the year 2000 and beyond is fairly alarming. There is a good correlation between fluctuations in CO_2, temperature increase and sea level rise.

- Recent work conducted since 1985 demonstrate that global warming is presently occurring. For example, a plot of the temperatures in the Northern Hemisphere for the last 500 years shows a temperature increase during the last 100 years. A change in temperature trends occurred around 1940 and more recently in the late 70's early 80s. This increase in temperature is more pronounced in the Northern Hemisphere.

  These changes have an impact on sea level rise. When comparing the mean rates reported for accretion of tidal mashes and the sea level rise along the Eastern and Gulf coasts of the United

States, it was observed that generally the sea-level rise is compensated by marsh accretion except in Blackwater (MD) and in Lake Calcasieu and Fourleague Bay (LA). In these locations subsidence is occurring.

- In addition, changes in land-surface precipitation have also been observed. These changes are driven in part by pollution associated with human activity. For example, Monday through Friday there is in general less precipitation than during the week-end and this has been correlated with car driving and the associated pollution.

  Seasonal alternation of dry and wet periods has been observed (ENSO). In 82/83 and 98 there were very large El Nino events. There was some changes in seagrass in the Suwanee River due to changes in precipitations as well as variation in the level of major lakes across North America.

- The time series of intense hurricanes making landfall on the Gulf and East coasts of the US between 1900 to 1990, show also that many hurricanes touched the Florida peninsula in the 1940s while very few were present after the late 60s. In the upper Atlantic region period of intense hurricanes occurred also in the 50s and there was also a quiet time in the 70s and 80s. Between 1900 and 1995, the frequency of major hurricanes is 2.6/year in the Gulf of Mexico and 3.5/year on the East Coast. When looking at correlation between precipitation and frequency of hurricanes, the frequency over the 46 wet years is 2.7 year in the Gulf and 1.8 along the East Coast while during the 46 dry years there was 2.8 /year hurricanes in the Gulf and 7.7/year along the East coast representing a large increase. During the period 1966-1984 there was 8 hurricane in the Gulf and no hurricane along the East Coast.

  These changes in precipitation are also seen in the Western Sahel where the rainfall have decrease since the late 1960s.

- The sea level have risen in the Gulf of Mexico near Galveston since 1910. In particular the mean high water level has risen. This has an impact on the health of the marshes. When high water increases by 1cm/y there is a loss of marshes and the habitat changes. The number of dying trees versus healthy changes in hammocks because of the tidal flooding .

What are the major weaknesses?

- The major weakness for short -term climate variability is the lack of an effective understanding of the system.
- For long-term climate change there is a lack of resolution and duration

What are the information and tools needed?

- Information:

Temporal records, point and spatial:

- Physical parameters: temperature, rainfall, tide gauge

- Habitat type: developed, natural, wetland, beach
- Ecological changes: wetland decline, coral bleaching

- Tools:

- Need some monitoring: instrumented, observational, remote
- Need data mining

8.2 Group I

1. What are the key issues related to this theme?

- What climate changes are predicted for coastal areas?
  Key areas of need:
  - historical context - past record
  - predictions for future changes
  - providing context for current studies (where in climate cycle are we?)
  - changes in sea level, precipitation, water flow, frequency/intensity of extreme events, etc.

- What are the possible impacts and consequences of these climate changes on natural resources, ecological processes, and humans in coastal areas?

- What non-climate related factors effect the impacts of climate change on natural resources, ecological processes, and humans in coastal areas? (e.g., Some decisions in coastal areas (land-use, fisheries etc.) may accentuate or modify the impacts of climate change on coastal resources)

- What can be done to mitigate impacts of climate change on natural resources, ecological processes, humans in coastal areas?

- How to make information on climate change impacts on coastal areas accessible and useful to broad management and research community?

- Need to make scales and issues of climate change a part of other studies, projects, programs in NCCOS (and beyond?).

2. What are the essential information and tools decision makers need to address these issues?

- Good databases on historical record of climate change
- General maps (GIS format) providing scenarios of past and future climate conditions.
  Examples of needs:
  - shoreline change and bathymetry
  - sea level rise

- precipitation
- atmospheric deposition
- water flows (watersheds and coastal waters)
- water conditions (salinity, temp, etc.)

- Information on past and possible future impacts of climate changes on coastal natural resources and ecosystem processes, humans in coastal areas.

  Examples: impacts on habitats, water quality, diseases, distribution of fisheries and nonindigenous species, costs and benefits
- Recognition of sources of information and access to this information (visibility)
- Better information and use of past, current and future land/water use, land/water cover

3. What are the scientific and technological impediments to developing and delivering this information and tools to decision makers that NCCOS should address?

- Limits to quality, quantity and accessibility of climate change data.
- Limits in predictive power etc. of climate models.
- Limits in availability and power of models predicting impacts of climate change on resources, ecosystems and humans in coastal areas.

  e.g., - Need more information on short and long-term responses of coastal resources to climate change
- Lack of long-term data on trends in coastal natural resources (Lack of long-term monitoring sites)
- Lack of knowledge of managers and other about what is currently available (lack of use of available information).
- Lack of specific sites/regions where existing climate change data and coastal resource data pulled together, models developed, applied, tested, assessments made of past and future climate impacts
- Managers not making decisions in context of possible impacts of climate changes

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Increase access to existing and new information related to climate change and impacts of climate change on coastal areas
  - Need to cross-link NCCOS
  - provide commonly accessible GIS-database with good support to build cross- links of data and overlay of information
  - provide training on GIS
  - standardize scales and information formats to make cross links possible
- Support maintenance of existing monitoring networks
  - precipitation, tides, water levels essential for others to maintain
- Evaluate current NCCOS and NOS monitoring efforts for use to climate change predictions.
- Develop models relating climate change impacts on coastal resources
  - continue COP climate change impact emphasis

- expand COP emphasis to coastal zone (land/sea margin)
- assess existing capabilities and expertise in NCCOS/NOS
- ID gaps and opportunities
- Produce maps of historic and possible future climate change impacts on coastal areas/resources
- ID key coastal indicators for predicting/tracking impacts of climate change on coastal areas/resources
- Provide assessments of climate change impacts on coastal areas/resources

8.3 Summary Groups I and II

1. What are the key issues related to this theme?

- What climate changes are predicted for coastal areas?
  Key areas of need:
  - historical context - past record
  - predictions for future changes
  - distinguish between natural and anthropogenic variability, climate change
  - providing context for current studies (where in climate cycle are we?)
  - Changes in water level, precipitation, water flow, freq./intensity of extreme events, etc.

- What are the possible impacts and consequences of these climate changes on natural resources, ecological processes, and humans in coastal areas?
  - What are the at-risk species, habitats, systems?
  - Identify key ecological linkages to predict impacts from climate change

- What anthropogenic (non-climate related) factors effect the impacts of climate change on natural resources, ecological processes, and humans in coastal areas?

  (e.g., Some decisions in coastal areas (land-use, fisheries etc.) may accentuate or modify the impacts of climate change on coastal resources)

- What can be done to mitigate impacts of climate change on natural resources, ecological processes, humans in coastal areas?

- How to make information on climate change impacts on coastal areas accessible and useful to broad management and research community?
  - Bridge scales between short-term management needs and scale/impacts of climate change
  - Define economic impacts and probabilities of climate change

- Need to make scales and issues of climate change a part of other studies, projects, programs in NCCOS (and beyond?).

2. What are the essential information and tools needed by decision makers to address these issues?

- Good databases on historical record of climate change
- Predictive models linking possible climate change and impacts on resources, ecological processes, and humans in coastal areas.

- General maps (GIS format) providing scenarios of past and future climate conditions.

  Examples of needs:
  - shoreline change and bathymetry
  - sea level rise
  - precipitation
  - atmospheric deposition
  - water flows (watersheds and coastal waters)
  - water conditions (salinity, temp, etc.)

- Information on past and possible future impacts of climate changes on coastal natural resources and ecosystem processes, humans in coastal areas.

  Examples: impacts on habitats, water quality, diseases, distribution of fisheries and non indigenous species, costs and benefits

- Recognition of sources of information and access to this information (visibility for NCCOS?)

- Better information and use of past, current and future land/water use, land/water cover

3. What are the scientific and technological impediments to developing and delivering this information and tools to decision makers that NCCOS should address?

- Limits to quality, quantity and accessibility of climate change data. (GENERAL LIMIT - NOT NECESSARILY FOR NCCOS TO ADDRESS)

- Limits in predictive power etc. of climate models. (GENERAL LIMIT - NOT NECESSARILY FOR NCCOS TO ADDRESS)

- Limits in availability and power of models to predict impacts of climate change on resources, ecosystems and humans in coastal areas.

  e.g., - Need more information on short and long-term responses of coastal resources to climate change
  e.g., - Need to couple climate change models with ecological process models

- Lack of long-term data on trends in coastal natural resources

- lack of long- term monitoring sites
- lack of up-to-date climatology (variability, extremes, expected values)

- Lack of knowledge of managers and other about what is currently available (lack of use of available information).

- Lack of specific sites/regions where existing climate change data and coastal resource data pulled together, models developed, applied, tested, assessments made of past and future climate impacts

- Managers not making decisions in context of possible impacts of climate changes

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Increase access to existing and new information related to climate change and impacts of climate change on coastal areas
  - Need to cross-link NCCOS
  - provide commonly accessible GIS-database with good support to build cross-links of data and overlay of information
  - provide training on GIS
  - standardize scales and information formats to make cross links possible

- Support maintenance of existing monitoring networks
  - precipitation, tides, water levels essential for others to maintain

- Evaluate current monitoring efforts in NCCOS and NOS for use to climate change predictions.

- Assess existing capabilities and expertise in NCCOS/NOS for climate change/impacts work
  - ID gaps and opportunities

- Develop models relating climate change impacts on coastal resources
  - continue COP/NCCOS climate change impact emphasis
  - expand COP/NCCOS emphasis to coastal zone (land/sea margin)

- ID key coastal indicators for predicting/tracking impacts of climate change on coastal areas/resources.

- Produce maps of historic and possible future climate change impacts on coastal areas/resources.

- Provide assessments of climate change impacts on coastal areas/resources.

- Fund additional research to fill information gaps on impacts of climate change on natural resources, ecosystems and humans in coastal areas

Proposed New Activities
To Build/Utilize NCCOS Abilities

Integration Activities

1. Workshops and Seminars to help set priorities and share information

2. ID capabilities and expertise of NCCOS units

3. Facilitate interdisciplinary efforts through staff exchanges, teams

4. Develop adequate NCCOS infrastructure to support interdisciplinary efforts

New Initiatives

1. Develop and utilize coupled models to predict/assess impacts of climate change on coastal resources, ecosystems, and communities.

2. Link models:
   - -climate
   - -meteorological
   - -hydrological
   - -habitat
   - -ecosystem
   - -socio-economic

   - need for ocean/Lake hydrodynamic -thermodynamic models

3. Select sites or regions
   - -Develop predictions
   - -Construct maps
   - -Assess outcomes

4. Links/Collaborations with National Centers for Environmental Prediction
   - model development
   - data sharing and development

9. Invasive Species, Species Decline and Biodiversity

Global transportation, habitat alteration, selective resource consumption, pollution, extreme events, and climate change are altering coastal and marine ecosystems, and may be causing the introduction of invasive species, the decline of species, and changes in biodiversity of different ecosystems. We need to take a holistic view of the impacts these activities are having on ecosystem processes on local and regional scales, and the role the individual species play in shaping ecosystem dynamics.

Speaker:	Donna Turgeon (CCMA)
Group I Chair:	Fred Kern (CCEHBR, Oxford)
Group II Chair:	Tom Siewicki (CCEHBR, Charleston)
Recorder	Karen Bushaw-Newton (CSCOR)

9.1 Speaker Summary

- Biodiversity:

"The collection of genomes, species and ecosystems occurring in a geographically defined region."

- Status of Marine Biodiversity
  - Reductions in most of the preferred edible fish and shellfish stocks
  - Altered aesthetic/recreational value of many coastal habitats (e.g. coral reefs)
  - Changes in composition/abundance of species or function of ecosystem

- Ultimate impacts of a growing population on marine biota.
  - Fisheries operations (e.g. Selective capture, Extraction, Bycatch, Habitat degradation, Ancillary impacts)
  - Chemical pollution and eutrophication (e.g. Nutrient/Hormone inputs, Disease)
  - Alterations in physical habitat (e.g. EFH removed, dredging, jetties, dams, water diversion, trawling, etc.).
  - Invasions of exotic species
  - Global climate change (e.g., atmospheric pollution, volcanic activity)

- Rate of extinctions about 100% of the natural background level and increasing
  - Native fish communities have decreased in distribution, decreased in diversity, and there has been and increase of the number of rate species,

Our Living Resources document, USGS, Mollusks 2nd ed., Turgeon et al. 1998

- Key-Issues

  - An-acknowledged global, long-standing problem exacerbated by human activities
  - Biodiversity and exotic introductions have been discussed before with little being done
  - CCMA/NMFS surveys

- Needed

  - Baseline surveys for coastal species
  - Estimates of trends factored into an index/report card
  - Prediction of future human effects

- Impediments

  - Paucity of reference materials and survey information
  - Few taxonomists
  - Lack of predictive models
  - Lack of political will and focus of human and fiscal resources

- NCCOS role

  - Conduct a research/survey/modeling program for coastal benthic faunal diversity
  - Monitor changes in coastal species abundance and correlative anthropogenic causes that can be factored into predictive models

- Initial Steps

  - Design an initiative to predict effects of human activities on biodiversity
  - Integrate findings from research efforts
  - Engage agency partners, leverage funds, and share data

9.2 Group I

1. What are the key issues related to this theme?

- Decline of Species Richness
- Stability of Ecosystems-Driving forces in the System?
  - Invasive species in the Great Lakes Ecosystem
  - Creation of unstable systems that are hard to predict

- Natural invasions vs assisted/intentional invasions.
- Displacement of Species (e.g. Copepod in San Francisco Bay) -possible reasons
  - unexploited niches
  - perturbations reducing native species allowing other organisms to take advantage
  - cascade effect
- Evidence of invasions is increasing worldwide but no large-scale sustained research efforts exist
  - some historical evidence (e.g. Cycle of Invasions)
- Increasing aquaculture has resulted in:
  - escape of exotic species
  - disease introductions (e.g. shrimp viruses)
  - genetic concerns (e.g. size of gene pool)
- Social and Economic Impacts
  - costs of control, mitigation, and prevention
- Extinctions and species decline progressing at a historically-high rate
- Anthropogenic changes
  - Chemical pollution
  - Physical
  - Activities-fishing, boating
- Loss of genetic diversity within species
  - Subspecific level loss
- Lack of quantitative understanding of extinctions in marine environment
- Role of Habitat loss/degradation/fragmentation on species diversity
- Habitat restoration
  - Is the restored habitat the same in function/form as before?
- Natural and Episodic events - what are the impacts
- Importance of Pathogen introductions
- Increased Pharmaceutical pollution
  - antibiotics, estrogens, etc...

2. What are the essential information and tools needed by decision makers to address these issues?

- Information on means for protecting reserves and sanctuaries (protected areas in general) from invasive species.

  Using protected areas as research tools
  - NERRS, and Marine Sanctuaries are areas of focused research, may already have issues dealing with invasive and species decline, and may be able to serve as base-line areas
  - provide information on permitting (ways to allow an activity to occur that is least destructive)

- Educational Process-
  - Need for clear explanation of species richness and how it effects the environment (Biological and Economic Roles, Baseline information)
  - Risk Assessment, Predictive capabilities (models), Triggers?

- Need for a selling point/Marketing tool
  (e.g. Brown tree snake)
- Identification of pathways
- Finding middle ground (Concerns of scientists and concerns of managers)
- Priority List of current problem areas
- Database Center

3. What are the scientific and technological impediments to developing and delivering this information and tools to decision makers that NCCOS should address?

- Lack of technical information on the following:
  - Few surveys that document impact/change
  - Enormity in numbers of species
  - Role of species in ecosystem
  - Reference guides
- Lack of funds $$$$$$$$$
- Lack of taxonomists
- Lack of specific programs across all agency lines and agencies
  - Make sure that invasive species, species decline, and biodiversity are a part of integrated multi- disciplinary approaches
- Working behind timeline
  - time scales
  - trends
- Lack of Predictive models
- Identify Federal Role (in general)

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- NCCOS initiative should be called: Changes in abundance of coastal estuarine species within initiative to be id:
  - Causes
  - Analytical component
  - Predictive component
- Creating networks and partnerships
  - Internal
  - External
  - Provides ways of information exchange and transfer
- Expand upon existing programs by:
  - adding diversity component
  - language in new AO's
- New program that spans agencies

- Make sure strategic plans of NCCOS and NOAA specifically deal with invasive species, species decline, and biodiversity
- Research needs
  - Create a center for quarantine and regulation of invasive species
  - Foster close integration of activities (research, monitoring, regulation, etc..)

9.3 Summary Groups I and II

1. What are the key issues related to this theme?

(Understanding Marine Biodiversity, National Research Council, 1995)

- Dramatic reductions in most of the preferred edible fish and shellfish species in the world's oceans;
- Reduction or loss of species with important potential for biomedical products;
- Altered aesthetic and recreational value of many coastal habitats, such as coral reefs, bays, marshes, rocky shores, and beaches;
- Vast changes in the species composition and abundance of the ecologically important animals and plants within and between impacted ecosystems; and
- Changes in the basic functioning of ecosystems, including the rates and sources of primary production, the stability of populations, the amount and direction of energy flow, and biogeochemical cycling."
- Assessing the impacts of aquaculture on the biodiversity of ecosystems including species introduction, disease introductions, stock enhancement, and genetic concerns.

Significant Concerns of the Key Issues

- Decline of Species Richness
- Stability of Ecosystems
  - Driving forces in the System?
  - Invasive species in the Great Lakes Ecosystem
  - Creation of unstable systems that are hard to predict
  - Ecosystem persistence and resilience
  - Severe alteration (e.g. Zebra mussel)
- Natural invasions vs assisted/intentional invasions.
- Displacement of Species (e.g. Copepod in San Fran Bay)
  - Possible reasons:
    - unexploited niches
    - perturbations reducing native species allowing other organisms to take advantage
    - cascade effect
- Evidence of invasions is increasing worldwide but no large-scale sustained research efforts exist

  - Some historical evidence (e.g. Cycle of Invasions)
- Increasing aquaculture has resulted in:
  - Escape of exotic species
  - Disease introductions (e.g. shrimp viruses)
  - Genetic concerns (e.g. size of gene pool)
  - Stock enhancement intentionally introduces exotic species, diseases, and genetic material with possible decline of wild stocks.
  - Organic nutrient enrichment
- Social and Economic Impacts
  - Costs of control, mitigation, and prevention
- Extinctions and species decline progressing at a historically-high rate
- Anthropogenic changes
  - Chemical pollution
  - Physical
  - Activities-fishing, boating
  - Pharmaceutical pollution (estrogens, antibiotics, etc...)
- Loss of genetic diversity within species
  - (Subspecific level loss)
- Role of Habitat loss/degradation/fragmentation on species diversity
- Habitat restoration
  - Is the restored habitat the same in function/form as before?
  - Invasive species
- Natural and Episodic events
  - What are the impacts?
- Importance of Pathogen and Parasite introductions

2. What are the essential information and tools needed by decision makers to address these issues?

- Identify and prioritize problem areas
- Taxonomic and genetic characterization
- ID of pathways
  - introductions
  - spread
- Research on methods to control introductions
- Ecosystem impacts
  - Aquaculture escapes
- ID differences between natural spread and spread accelerated by human activities
- ID genetic impacts
- Use of NERRS and Marine Sanctuaries for research

3. What are the scientific and technological impediments to developing and delivering this information and tools to decision makers that NCCOS should address?

- Lack of historical information
- Lack of rapid, technical identification methods
- Interjurisdictional issues
- Lack of predictive models
- Lack of quantitative understanding of extinctions
- Programmatic impediments
  - Lack of funds
  - Lack of trained taxonomists
  - Lack of interagency planning and coordination
  - Lack of integrated, multi-disciplinary approaches

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Historical and baseline data
- Long term, sustained program
- Improved taxonomic techniques
- Assessment of the impact of invasive species on ecosystem function
- Characterize sensitivity of ecosystems to invasions
- Design better ways to track biodiversity
- Create center for research and regulation of invasive species
- Programmatic
  - Create networks and partnerships
  - Add diversity component to existing programs and new RFPs
  - Include invasive species, species decline, and biodiversity in NCCOS and NOAA strategic plans

10. Using Science and Technology to Address Multiple Stressors

Our Nation's ecosystems are effected by a wide variety of natural and human-induced stressors, including land and resource use, invasive species, pollution, extreme natural events, and climate change. These stressors often interact synergistically and antagonistically, and as a result their cumulative impacts on ecosystem structure and function are poorly understood and difficult to assess or manage. With the emerging technologies of the 21st century, we are poised to make a quantum advance in finding a common currency or a suite of techniques to address the impacts of multiple stresses. These new technologies include genome sequencing, DNA chips, and other new biotechnologies for understanding how biological processes are controlled by genetic limitations and environmental variables; new software for computational analysis, modeling, and simulation; advanced models for ecosystem complexity, integrated assessments, and analysis of management options; new biosensors and biogeochemical tracing techniques; ecological monitoring devices; satellite-based imaging of landscapes and waters; and, networked data for better integrated and more accessible information.

Speaker:	Curtis Olsen (NCCOS)
Group I Chair:	Peter Landrum (GLERL)
Group II Chair:	Sue Banahan (CSCOR)
Recorder:	Mike Murphy (NCCOS)

10.1 Speaker Summary

- Various tools and techniques can be used to address issues facing coastal ecosystems including:
  - land and resources use
  - invasive species and species decline
  - pollution including excess nutrients
  - extreme natural events
  - atmospheric and climate change

- The spatial and temporal scale to be considered spans 15 orders of magnitude.

- Examples of science and technology currently include:
  - Molecular Biological Techniques for Mechanisms and Responses
  - Isotopic Tracer Techniques for Net Effects
  - Instrumentation for In-situ Field Measurements
  - Remote Sensing for Land/Water Linkages
  - Advanced Models & Information Networks for Predictions and Management

10.2 Group I

1. What are the key issues related to this theme?

- Better way to distinguish sources and types of stressors
- Better way to quantify effects of stressors
- Need to understand interactions among stressors - antagonism/synergism
- At what level(s) do you measure stress - (e.g., molecular, organism, population, ecosystem)
- Communication of issues, problems, and recommendations to managers
- Determine socio-economic impacts
- Need to encourage ecosystem-level hypothesis development
- Inadequate information available to decision makers - need information on historical context, what is the system like today (what different), and can you predict what the system will be like in the future with given management actions (or no actions)

2. What are the essential information and tools needed by decision makers to address these issues?

- What are the conditions of a non-stressed ecosystem and how do you measure state and function?
- Need to have follow-up to demonstrate effectiveness of management decisions
- Establish goals from scientific recommendations that meet public expectations for improvement
- Need to develop effective visualization tools so decision makers can understand the problems
- Need socio-economic information of what aspects of society have caused the problem, what aspects of society do we have to change, what are the benefits of that change to society, and what would be the consequence of not doing anything at all.

3. What are the scientific and technological impediments to developing and delivering this information and tools to decision makers that NCCOS should address?

- Limited data for functional linkages and interactions between organisms, habitat, contaminants, etc. at all levels
- Unable to accurately distinguish sources of stressors, and importance of individual stressors to one another
- Often disagreement on proper definition of the problem and consensus of what the problem is
- Need to establish baseline data, and have adequate monitoring of system
- Inability to measure contaminants in real-time or near real-time
- Need to adapt and develop cutting edge technology to in situ use
- Need to have adequate measures of ecosystem conditions that represent a non-stressed system, e.g., resilience, persistence, ecosystem values, etc.
- Do not follow-up management decisions to know if they had an impact

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Bio-chemical and chemical probes
- New data tools, including analysis and visualization techniques
- Improved Techniques in remote sensing, and isotope tracers
- Develop models to improve communication and understanding of research
- Need better coupling of physical/biological/chemical, etc. systems & models
- Need automated instrumentation
- Need to have high-risk research
- Link socio-economic impacts into research and modeling framework

FY 2001

- Make sure its an inter-disciplinary research program
- Position to be established within NCCOS cumulative stressors dedicated to communications and integration
- Develop and adapt management and technological tools that improve multiple stressor science and management decisions
- Need to do coordinated, ecosystem oriented research and monitoring studies, (allows you to make informed decision when unexpected situations arise in future)

10.3 Group II

What are the key issues related to this theme?

- Many estuaries and coastal waters are suffering from multiple stressors
- Inability to convey to public the effects of multiple stressors on the coastal environment
- Need to identify and classify stressors
- Determine stressor interactions with one another, and within the environment

2. What are the essential information and tools decision makers need to address these issues?

- Who are your constituents? (E.g., land-use managers, environmental protection agencies, etc.)
- What are your constituents needs?
- Need to know the difference between the effects of natural vs. anthropogenic stressors
- Need to know socio-economic impacts of different management scenarios, (e.g. modeling, risk assessment)
- Visualization tools to communicate stressor/resource issue
- Decision analysis models
- Development of index of degree of stress in ecosystems

- Need to identify and classify stressors, and determine impacts

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Methods for identifying multiple stressors, e.g., indicators, identification of specific stressors
- Lack of baseline data
- Lack of public/agency support
- Identification of indirect and/or sub-lethal effects
- No expertise in socio-economic impacts of stressors (within NCCOS)
- Methods for isolating sources, i.e., where is it coming from?
- Standardized way of exchanging information across NCCOS & NOAA
- Cost-effective ways of in situ in near real-time monitoring
- No experimental, conceptual, numerical approaches to quantify effects of stressors

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Develop/refine experimental techniques like mesocosm to look at effects, processes, kinetics, spatial, temporal (i.e., sequential stressors)
- Examine how stressors effect genetic structure/diversity, trophic complexity
- Demonstrate research outcomes to constituents, e.g., economic & environmental benefits, explain approach and decisions
- Develop modeling framework for integrating research in a particular site/region
- Developing methods (e.g., molecular, organismal, water quality parameters, habitat parameters, etc.) to identify and quantify impacts
- "Build up the tool box", e.g.,
    - Tools that monitor stress
        - in situ water quality instruments
    - Tools that monitor the effect
        - Physiological - methods to monitor the physiological effect
        - Environmental - remote sensing
- Environmental risk assessment models
- Develop distributive data systems
- Importance of interdisciplinary research projects
- Streamlining the MOU importance
- retrospective analyses

10.4 Summary Groups I and II

1. What are the key issues related to this theme?

- Many estuaries and coastal waters are suffering from Multiple Stressors (MS)
- How do we manage for the cumulative impacts of MS
- Need to identify and classify stressors, and their effects
- Need to understand interactions among stressors - antagonism/synergism
- Communication of issues, problems, and recommendations to managers and users (also impediment)
- Inadequate information available to decision makers - need information on historical context, what is the system like today (what is different), and can you predict what the system will be like in the future with given management actions (or no actions)

2. What are the essential information and tools decision makers need to address these issues?

- Who are your constituents and what do they need to know?
- Need to know socio-economic impacts of different management scenarios, (e.g. modeling, risk assessment)
- Establish goals from scientific recommendations that meet public expectations for improvement
- Demonstration of the effectiveness of management decisions
- Visualization tools to communicate stressor/resource issue

3. What are the scientific and technological impediments to developing and delivering information and tools to decision makers that NCCOS can/should address?

- Methods for identifying multiple stressors, e.g., indices, identification of specific stressors
- Limited baseline data
- Cost-effective ways of in situ, near real-time monitoring
- Insufficient experimental, conceptual, or numerical approaches to quantify effects of stressors
- Lack of follow-up on the efficacy of management decisions
- Limited data for functional linkages and interactions between organisms, habitat, contaminants, etc. at all levels
- Unable to accurately distinguish sources of stressors, and importance of individual stressors to one another

4. What research, monitoring, modeling, and assessments need to be implemented through NCCOS to overcome these impediments?

- Development of indices of stress
- Standardizing information exchange across NCCOS and NOAA
- Need to adapt and develop cutting edge technology for in situ use

- Need to have adequate measures of ecosystem conditions that represent a non-stressed system, e.g., resilience, persistence, ecosystem values, retrospective analyses
- Develop models to improve communication and understanding of research
- Need better coupling of physical/biological/chemical systems & models
- Link socio-economic impacts into research and modeling framework
- Develop/refine experimental techniques like mesocosm to look at effects, processes, kinetics, spatial, temporal (i.e., sequential stressors)
- Examine how stressors effect genetic structure/diversity, trophic complexity
- Demonstrate research outcomes to constituents, e.g., economic & environmental benefits, explain approach and decisions
- Build up the "tool box" by developing methods that monitor stressors and their effects, (e.g., molecular probes, remote sensing, etc.)

FY 2001

- Develop and adapt management and technological tools that improve multiple stressor science and management decisions
- Need to do interdisciplinary, ecosystem oriented research and monitoring studies, (allows you to make informed decision when unexpected situations arise in future)

PART II

Key Research Issues and Needs — A Summary of the Retreat

Part II of this Report summaries the deliberations of the Theme Areas with the ultimate objective of focusing program direction and identifying a limited number of potential initiatives for NCCOS. To summarize and condense emergent issues and needs from the retreat, a matrix that identifies information gaps and suggested approaches toward filling these gaps, common among Theme Areas, was constructed and supplemented with bullet-summaries of Theme-Area discussions. To reduce the number of Themes, from ten to five, Theme Areas were amalgamated by these common issues and needs. The five combined Themes that resulted, were finally aligned with NOS Synergy Topics and CENR Priorities.

Theme Area / Component Matrix

The following matrix was constructed in an effort to search for common information needs and suggested approaches among Themes (i.e., Break Out Groups). Columns, listed across the top, are "Theme Areas"; rows, listed down the left, are common issues or "Components." Components that emerged once were excluded. Some topics (e.g., the need to link physics and biology or to identify cause and effect) were recurrent, but were merged under a single composite component (e.g., "Defining Processes and Mechanisms"). Cross symbols indicate that the issue was discussed in the discussions of Breakout Groups.

It was apparent from this exercise that NCCOS investigators know the critical information gaps, what issues are important, and how to conduct the requisite science that will address these issues and fill these gaps. Most Break Out Groups recognized the need to build time-series data sets through monitoring and retrospective analyses, to define and describe the mechanisms of cause and effect through process oriented studies, to define variation (in time and space) in these processes, and to construct predictive models that can be applied to forecasting change in ecosystems. Remote sensing, in various forms, was recognized as the modern method of accumulating synoptic data sets. All recognized the need to assess the societal cost of change and to distribute the scientific information acquired.

Table 1. Matrix of Theme Areas to Research Components

Theme Area / Research Component	Species	Multiple Stressors	Indicators	Toxics	Eutro.	HABs	Habitat	Ocean Change	Climate Change	Forecast/ Hazards
Monitoring/Time Series (building data sets)	x	x	x	x	x	x	x	x	x	x
Retrospective Analysis (e.g., paleoecology, climate, etc.)	x				x	x	x	x	x	x
Defining Process/ Mechanisms	x	x	x	x	x	x	x	x		x
Modelling	x	x	x	x	x	x	x	x	x	x
Resilience/Fungibility (looking for possible remediation)			x			x	x	x	x	
Prediction / Forecast	x					x	x	x	x	x
Varability (natural - anthro)	x		x	x			x	x	x	
Criteria Reference (inpact - noninpact)			x	x		x	x		x	
Scaling	x	x	x	x	x	x	x	x	x	x
Remote Sensing		x	x		x	x	x	x	x	x
Thresholds of Response		x	x	x			x			
Need for Taxanomic Life History	x	x				x	x	x		
Study Areas				**NERRS**	**NERRS**		x	**Refugia**	x	x
Boundary Interactions									x	x
Indicies of Change		x	x			x	x			
Cumulative Impacts		x	x				x			
Societal Costs / Outreach (Assessments & Education)	x	x	x	x	x	x	x	x	x	x

Key Research Issues/Needs Summarized from Theme Area Discussions

This section of the report summarizes and extracts the most important issue(s), question(s) to be addressed, and needs essential to solve the problems that surfaced during the discussions of the breakout groups for each theme areas.

1. Coastal Environmental Indicators:

Issue: Coastal ecosystems are heavily influenced by many natural events and human activities.

What are the criteria for reference "impacted vs non-impacted" systems?
What is the impact of stressors on long-lived animal/plants?
What are the differences between acute and chronic stressors?

Needs: A National program that will:

- evaluate the status of ecosystem health
- define how changes are occurring both in time and in space.
- develop and assess the tools to monitor these changes
- differentiate responses to multiple stressors and differentiate these responses from natural events.
- determine what indicator(s) should be used recognizing that indicators alone cannot supply all the needed information.

2. Toxic Contaminants:

Issue: A wide range of organic and inorganic chemical contaminants are effecting coastal ecosystems but correlation between chemical concentrations and bioeffects is not well understood. In addition, the types, loadings and sources of toxic contaminants are changing.

What are the normal and perturbed states?
What are the background levels of toxic contaminant?
What is the variability of these background levels and what is the meaning of the variability?
What are the right chemicals to look for?

Needs:

- determine the location, spatial extent, source, and impact of toxic contaminants and their proximity to sources.
- understand the relationship between measured concentrations and toxicity/bioeffects.

- understand the effects of contaminant mixtures and their interaction with other stressors - and - the effects of multiple stressors on various components of the environment (trophic levels, etc.)
- provide coastal managers with realistic mitigation scenarios.

3. Eutrophication:

Issue: Perceived degraded or declining ecosystem health with causes generally attributable to land use changes and other anthropogenic sources of excess nutrients.

What is the definition of eutrophication?
What are its manifestations?
What are the key controlling variables driving a system towards eutrophication?
What is the biota response to changes in trophic status?

Needs: A National program that will take a holistic approach to:

- better understand the interaction of changing land use practices, natural climatological events, food web dynamics with respect to assimilating nutrient loads.
- determine the causes, effects and (cumulative) impacts of eutrophication.
- determine which management practices are cost effective and reduce eutrophication.

4. Harmful Algal Blooms:

Issue: The occurrence of HABs in coastal areas appears to be increasing in frequency, distribution, severity and type and the linkages between human activities and HABs are not well understood.

What is the relationship between HABs and human activities?
What are the ecological effects, public health and socio-economic impacts of HABs?
Can HABs be managed? Predicted/ Forecasted, prevented, controlled?

Needs: We need an integrated program that:

- combines research, modeling, monitoring, and assessment
- will determine the economic and ecological impact of HABs
- develop the capability to predict and mitigate their occurrences.

5. Oceanographic Variability:

Issue: Oceanographic change occurs over a variety of time scales and influences the distribution and abundance of living marine resources and the ecosystems upon which they depend.

What are the critical scales (temporal, spatial) of oceanographic changes that effect function and structure of ecosystems?
How resilient species, communities, and ecosystems are to these changes.
Which part of the life cycle of an organism is most effected by oceanographic changes?

Needs: Develop multi-disciplinary teams to:

- determine critical time and space scales and how they effect the structure and function of coastal ecosystems.
- determine species resilience
- define and describe water column/pelagic habitat use.
- determine how these changes effect management strategies.

6. Coastal Forecasting, Natural Hazards and Water Resources:

Issue: As coastal populations, shoreline development, and use of coastal resources continue to increase so do threats to life and property, risk to ecosystems and the depletion of our natural resources.

What is the impact of extreme events on coastal areas/ecosystems?
What is the exact coast?
What is the role of forecast in protecting the coastal ecosystem?

Needs:

- understand the complex physical-ecological coupling in coastal areas.
- develop accurate high resolution nowcasts and forecasts of coastal physicsl processes.
- understand and assess the cause, effects and impacts of episodic and extreme events on ecological systems.
- develop representative risk-based decision-making models for select but broad management applications.
- understand and assess effects of coastal development and extreme events on water resources

7. Climate Variability and Change:

Issue: Coastal ecosystems are susceptible to climate variability and change.

What climate changes are predicted for coastal areas?
What are the possible impacts and consequences of these changes?
What anthropogenic factors effect the impacts of climate change on natural resources, ecological processes, and humans in coastal areas?
What can be done to mitigate these changes?

Needs:

- maintain existing and/or develop new monitoring networks (precipitation, sea level, etc.)
- develop models relating climate impacts on coastal resources.
- identify key coastal indicators for predicting/tracking impacts of climate change on coastal areas/resources.
- provide assessments of climate change impacts on coastal areas/resources.

8. Habitats:

Issue: There is a need to characterize the biological, physical, and chemical characteristics of habitats as a basis for evaluation over time.

What and where are the habitats and how much is there?
What is the spatial and temporal variability within habitats.
What the linkages between and among habitats?
How do they contribute to ecosystem function?
How do anthropogenic and/or natural disturbances effect habitat function?
How does one define successful restoration?

Needs:

- understand the natural variability and enhance our ability to detect and predict change.
- retrospective analysis of long term data sets.
- better quantification of habitat loss.
- experiments that address interactions of multiple stressors at acute, chronic and sub lethal levels.
- define utilization of habitats by species' life stages.

9. Invasive Species, Species Decline, and Biodiversity:

Issue: We see reduction in many preferred edible fish and shellfish stocks; altered asthetic/recreational value of many coastal habitats; and changes in composition/abundance of species or function of ecosystem. (Long-standing problem exacerbated by human activities)

What is causing the observed decline in species richness?
What are the social and economic costs of invasions and species shifts?
What is the role of habitat changes?

Needs:

- baseline surveys for coastal species.
- determine/predict effects of human activities on biodiversity.
- monitor changes in coastal species abundance and correlative anthropogenic causes.

10. Science and Technology to address Multiple Stressors:

Issue: Coastal ecosystems are suffering from natural, climate oceanographic changes and human-induced stressors, including harmful algal blooms (HABs), toxic contaminants, coastal eutrophication, nonindigenous species, land cover and land use change, and habitat degradation. These stressors often act synergistically and antagonistically, and as a result their cumulative impacts on ecosystem structure and function are poorly understood and difficult to assess and manage.

What is the condition of a non-stressed ecosystem?
How do you measure state and function?
What is the level of stress that can be measured?

Needs:

* Need a National Program to:

- evaluate coastal ecosystem health with a modest number of complementary indicators that describe ecosystem pattern and function identify, classify, and monitor stressors.
- develop strategy to identify chemicals of concern and their impacts including screening for endocrine disruption, reproduction, developmental alteration, growth modification, etc.
- develop an understanding of habitats and biological species most at risk from different classes of chemicals.
- better characterize chemical types, loadings, and sources.
- determine the spatial extent, location, and variability of chemical exposure and its relationship to recipient habitats
- better understand the relation between chemical exposure, biological responses, and detrimental effects to valued living resources
- assess the utility of proposed biomarkers as inferential tools in linking chemical exposure, biological responses, and detrimental effects.
- develop a predictive capability to infer population, community, and ecosystem level responses from measurements at the biochemical, cellular, and physiological with individual organisms.
- better understand the interactions of multiple chemical stressors as well as their interaction with other environmental factors such as temperature, salinity, nutrients, and light.

- develop tools that allow the identification of the principal chemical contributors to detrimental effects within a mixture of multiple stressors so that source reduction and remediation can be targeted.
- develop tools that can differentiate the influence of anthropogenic activities from natural
- develop and adapt appropriate measurement technology to field observation and sampling
- understand how stressors effect genetic structure/diversity, trophic complexity, etc.
- understand the interactions among stressors.
- determine adequate measures of ecosystem conditions that represent a non-stressed system.
- build new indicators

<u>Possible NCCOS Themes</u>

After reviewing comments from the break out groups certain themes appear to have similar issues, impediments, and/or needs. This part of the report represents an effort to regroup and organize the themes around wider scientific topics. However, some needs were common to most of the themes. They include the need to:

- better understand the coupling between physical, chemical, and biological systems,
- have long-term monitoring/data and baselines against which changes can be assessed,
- develop pertinent models, and user-friendly visualization tools, and
- assess societal costs associated with the changes observed in the coastal ocean.

1. Role of multiple stressors on coastal ecosystems and the development of environmental indicators

Includes Theme Areas:

-Coastal environmental indicators
-Toxic contaminants
-Science and technology to address multiple stressors to coastal ecosystems

At the workshop, the discussion of these three theme areas were mostly centered around the role of multiple stressors and the indicators needed to allow the differentiation between the various stressors. For example, in the toxics workgroup, most of the concerns were expressed in terms of mixtures of chemicals and the difficulty in separating the role of natural events from anthropogenic factors.

Main Issues

* *Ecosystems are changing (degrading as a result of multiple anthropogenic stressors, improving as a result of remedial actions, responding to natural events at various time scales)*
* *Many estuaries/coastal /Great Lake areas are suffering from the cumulative impact of multiple stressors, natural and anthropogenic, while toxic contaminants act in concert with other stressors*
* *A wide range of organic and inorganic chemical contaminants are effecting coastal ecosystems and the types, loadings and sources are changing.*
* *We do not know how changes are occurring on temporal/spatial scales*
* *We do not know what are the best indicators or combination of indicators to provide assessment of ecosystem health*

Needs

* Need a National Program to:

- ○ evaluate coastal ecosystem health with 6 or so good indicators

- * Need to:
  - ○ identify chemicals and their toxic impacts
  - ○ better characterize toxic chemical types, loadings and sources and how these are changing
  - ○ know what is the spatial extent and location of toxic contaminants
  - ○ know what are the relationships between concentration, effects and toxicity of a chemical
  - ○ know what are the effects of multiple chemical exposures
  - ○ screen chemical effects for endocrine disruption, and for modification of growth, reproduction and development, etc.
  - ○ understand better the effects of toxic contamination in order to manage better our coastal resources
  - ○ know the natural range of biomakers and their response to chemical contamination.
- * No tools exist to monitor these changes; we need to
  - ○ develop tools that:
    - differentiate responses to multiple stressors,
    - differentiate anthropogenic activities from natural events
  - ○ develop and adapt cutting edge technology to *in-situ* use

2. Eutrophication and HABs

Includes Theme Areas

-Eutrophication
-HABs

It has been demonstrated that some, but not all, harmful algal blooms are nutrient-driven. However, these two themes could be combined since both are dealing with plankton ecology.

Main Issues

- * *Public perception that coastal ecosystems are degraded or the health of ecosystem is declining due to anthropogenic pressures (ex: Food web effects-species shifts, food quality; anoxia/hypoxia; HABs; Habitat degradation/loss; Water quality).*
- * *The occurrence of HABs in coastal areas appears to be increasing in frequency, distribution, severity and type and the linkages between human activities and HABs are not well understood.*

Needs

- * A National program that will take a holistic approach to:
  - ○ better understand the interaction of changing land use practices, natural climatological events, food web dynamics, etc.
  - ○ determine the causes, effects and (cumulative) impacts of eutrophication.
  - ○ determine if management practices are cost effective and reduce eutrophication.

* In addition, we need an integrated program that will:
  - combine research, modeling, monitoring, and assessment to:
    -understand the linkages between human activities and HABs
    -determine the economic and ecological impact of HABs and
    -develop the capability to predict and mitigate their occurrences.

3. Changes in habitat and species biodiversity

Includes Theme Groups

-Habitat
-Invasive species, species decline, and biodiversity

Taking the term "Habitat" in a large sense that includes the physical, chemical, biological, and dynamic aspects of it, it seems rational to relate these two themes. Degradation or changes in habitat will trigger changes in biodiversity and in the species present.

Main Issues

* *Many preferred edible fish and shellfish stocks are decreasing; the aesthetic/recreational value of many coastal habitats is altered; and changes in composition/abundance of species or function of ecosystem are observed.*
* *Characterization of habitat function (on temporal, and spatial scales) is insufficient. Coastal habitats are effected by multiple factors/stressors.*
* *Responses of fishery organisms to habitat modification are pporly understood.*

Needs:

* Need to know:
  - the impact of growing population on marine biota
  - the role of habitat loss/degradation/fragmentation in the loss of biodiversity
  - How habitats contribute to ecosystem function?
  - How anthropogenic and/or natural disturbances effect habitat function and biodiversity?
  - In restoration science, how does one define successful restoration?
    -needs criteria for success
    -methods evaluations
    -tools

* Need to characterize the biological, physical, and chemical parameters of habitats to:
  - understand the natural variability and enhance our ability to detect and predict change, using retrospective analysis of long term data sets, baseline surveys and monitoring.
  - better quantify habitat loss.
  - define utilization of habitats by species' life stages.

* Need to better measure the cumulative impact of multiple stressors

4. Role of climate and oceanographic changes/variability on coastal ecosystems-physical/ecological coupling

Includes Theme Groups

-Climate changes and variability
-Oceanographic changes

In nature, climatic and oceanographic factors are often linked. For example high winds will generate strong waves and currents. On the other hand changes in ocean temperatures may trigger climatic changes such as the ENSO phenomena. This is the reason why these two topics are combined in this section.

Main Issues

* *Global climate change and related sea level rise have been observed.*
* *Oceanographic change and climate variability occur over a variety of time scales.*
* *Coastal ecosystems are effected by climate and oceanographic changes. These changes influence coastal ecological processes and the distribution and abundance of living marine resources.*
* *Changes will occur in the future. To mitigate the effects of these future climatic and oceanographic changes, knowledge of the type of changes and their consequences would be invaluable*

Needs:

* Develop multi-disciplinary teams to:
    - Determine the critical scales of oceanographic and climatic variation that effect the structure and function of coastal ecosystems using coupled physical, chemical and biological approach.
    - Determine how resilient species, communities, and ecosystems are to these changes.
    - Predict impacts of the expected natural variabilities (ex: ENSO, etc.).
    - Assess climate change impacts on coastal areas/resources.
    - Assess the role of anthropogenic factors on climate changes (fisheries, land use,...)?

* Need to make progress in:
    - Understanding the differences between natural variability and changes created by anthropogenic activity
    - Maintaining existing and/or developing new monitoring networks (precipitation, sea level, etc.)
    - Developing numerical models of circulation and hydrology coupled with biological models (multispecies modeling and data assimilation)
    - Identifying key coastal indicators for predicting/tracking impacts of climate change on coastal areas/resources.

5. Impact of extreme events on coastal ecosystems

Includes Theme Group

-Coastal forecast systems, natural hazards, water resources

NOAA must build and refine its capability to forecast water levels, erosion, storm surge, currents, and wave heights not only to support maritime services, but also to protect the general public. Knowledge of these physical processes is needed to improve the predictive capability for protecting lives and property from natural hazards, and to more efficiently allocate water resources.

Main Issues

* *As coastal populations, shoreline development, and use of coastal resources continue to increase so do threats to life and property, risk to habitats and ecosystems, and the depletion of our natural resources.*

Needs:

* Develop accurate high resolution nowcasts and forecasts of coastal physical and ecosystem processes.
* Collect long-term high-resolution data and observations
* Understand and assess the cause, effects, and impacts of episodic and extreme events on biological and physical systems.
* Develop representative risk-based decision-making models for selected but broad management applications.
* Develop analysis techniques for multivariate extreme and asymptotic distributions of physical and biological events and correlated forcing factors.

Priority areas

NOAA's strategic planning and budget formulation process begins almost two years before Congress completes its consideration of a Presidential budget and provides appropriations to Federal agencies. Planning two years in advance is necessary to allow time for development of initiatives and their presentation and review at different organizational levels of the budget formulation process (i.e., NOAA, DOC, OMB, Congress) (Figure 1).

An important first step in developing research initiatives for NCCOS is to begin identifying opportunities related to ideas generated from the NCCOS retreat so they can be presented to participants of the NOAA strategic planning and budget process beginning this fall. These opportunities are usually associated with priorities established at the different review levels of the budget formulation process.

For example, the NOS leadership will begin a series of budget meetings this fall. These meetings will likely be focused around five synergy areas that NOS leadership has identified as budget priorities across its programs and organizations. The FY 2000 synergy topics are:

Habitat
Nutrient Pollution
All Hazard Response
Marine GIS Development
Dredging

Initiatives developed from the NOS meetings will then be submitted to each of the NOAA strategic planning team via NOS representatives to those teams. The strategic planning teams will take ideas from all the NOAA line offices, as well as priorities identified by constituents, and formulate them into comprehensive initiatives. These initiatives are presented by the teams to NOAA senior management in the following spring for review and decisions on priorities that NOAA will pursue through its FY 2001 budget request to DOC. These first two phases of the budget formulation process (i.e., development of the NOS and strategic planning team initiatives) offer the broadest opportunity for bringing issues and ideas to the attention of NOAA. The focus of these two phases is primarily on reaching consensus on priorities that should be addressed within the scope of the NOS mission and strategic planning team goals, and identifying the appropriate application of capabilities across NOAA that should address these priorities.

The subsequent levels of review by DOC and OMB focus on consideration of the priorities identified at the previous phases of the budget formulation process, and comparison of the relevance of proposed initiatives to priorities of the Department and the Administration. These include other processes which parallel the agency budget formulation process. For example, Presidential initiatives are often introduced complementary from an agency's formal budget request, influencing decisions about policy and budget priorities. These initiatives may result from major policy initiatives not previously identified in budget formulation guidance to agencies. They also result from structured mechanisms for coordinating efforts across the government. An example of one of these mechanisms is the President's Committee on the Environment and Natural Resources (CENR) which was established to coordinate science across Federal agencies. Over the past several years, CENR has worked with Federal agency representatives to established priority areas for coordinated science efforts. These priorities are reflected in the Administration's guidance on preparing agency budgets, and are often an important consideration at the higher levels of budget review. For coastal ocean science, CENR is pursuing an Integrated Science for Ecosystem Challenges (ISEC) program, which has identified five "ecosystem challenges" to guide federal coordinating efforts and for identifying annual priorities:

- Land and Resource Use
- Invasive Species
- Pollution
- Extreme Natural Events
- Atmospheric and Climate Change

Relevant other priorities identified by the CNER include Climate and Global Change and Natural Disaster Reduction.

There are many factors which influence the probability that an initiative will be successful at the different review levels of the budget formulation process. The following are some key considerations to that ultimate success:

1) Initiative includes a clear explanation of the issue, science needs, and anticipated benefits.

2) Initiative falls under one of the NOS synergy topics and is integrated with other NOS programs.

3) Initiative is cross-cutting across NOAA organizations and programs.

4) Initiative is cross-cutting across DOC or other Federal agencies (e.g., through the CENR process).

In Table 2, the five consolidated NCCOS theme areas are linked to the NOS synergy topics and the CENR priorities to show how the NCCOS initiatives could be related.

Table 2. Relation of NCCOS Theme Areas to NOS Synergy Areas and CENR Priorities

NCCOS Retreat Common Theme Areas	NOS Synergy Areas	CENR: Challenges to Ecosystem Sustainability (ISEC Strategy)	Other CENR Priorities
Multiple Stressors & Environmental Indicators	Habitat & Dredging	Land and Resource Use	
Eutrophication & Harmful Algal Blooms	Nutrient Pollution & All Hazards Response	Pollution	
Changes in Habitat and Species Biodiversity	Habitat & Marine GIS	Invasive Species	
Effects of Oceanographic and Climate Change on Coastal Ecosystems	Habitat	Atmospheric and Climate Change	Climate and Global Change
Effects of Extreme Events on Coastal Ecosystems	All Hazards Response & Marine GIS	Extreme Natural Events	Natural Disaster Reduction

NCCOS Retreat Participant List

NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE HEADQUARTERS (NCCOS)

N/COP, Rm. 13501
1305 East-West Highway
Silver Spring, Maryland 20910
Phone: (301) 713-3060
Fax: (301) 713-4270
Senior Scientist: Don Scavia
Email: Don.Scavia@noaa.gov
Secretary: Paula Stuart

Staff	Email Address
Julia Blackwell	Julia.Blackwell@noaa.gov
Bud Cross	Bud.Cross@noaa.gov
Jeff Govoni*	Jeff.Govoni@noaa.gov
Curt Mason	Curt.Mason@noaa.gov
Darrell McElhaney	Darrell.Mcelhaney@noaa.gov
Michael Murphy	Michael.T.Murphy@noaa.gov
Curtis Olsen	Curtis.Olsen@noaa.gov
Nancy Ragland	Nancy.Ragland@noaa.gov
Don Scavia	Don.Scavia@noaa.gov
Tim Tisch	Timothy.Tisch@noaa.gov
Nathalie Valette-Silver*	Nathalie.Valette-Silver@noaa.gov

*Rotational Assignment

CENTER FOR COASTAL MONITORING AND ASSESSMENT (CCMA)

N/ORCA2 Rm. 10110
1305 East-West Highway
Silver Spring, Maryland 20910
Phone: (301) 713-3032
Fax: (301) 713-4388
Director: Andrew Robertson
Email: Andrew.Robertson@noaa.gov
Secretary: Sophie Bowen

Staff	Email Address
Adriana Cantillo	Adriana.Cantillo@noaa.gov
John Christansen	John.Christansen@noaa.gov
Bernard Gottholm	B.William.Gottholm@noaa.gov
Jawed Hameedi	Jawed.Hameedi@noaa.gov
Michelle Harmon	Michelle.Harmon@noaa.gov
Jeff Hyland	Jeff.Hyland@noaa.gov
Edward Johnson	Ed.Johnson@noaa.gov
John Klein	John.Klein@noaa.gov
Gunnar Lauenstein	Gunnar.Lauenstein@noaa.gov
Ed Long	Ed.Long@noaa.gov
Mark Monaco	Mark.Monaco@noaa.gov
Tom O'Connor	Tom.OConnor@noaa.gov
Andrew Robertson	Andrew.Robertson@noaa.gov
Hal Stanford	Hal.Stanford@noaa.gov
Rick Stumpf	Rick.Stumpf@noaa.gov
Donna Turgeon	Donna.Turgeon@noaa.gov

CENTER FOR SPONSORED COASTAL OCEAN RESEARCH (CSCOR)

N/COP, Rm. 9700
1315 East-West Highway
Silver Spring, Maryland 20910
Phone: (301) 713-3338
Fax: (301) 713-4044
Acting Director: David Johnson
Email: David.Johnson@noaa.gov
Secretary: Tracie Ross

Staff	**Email Address**
Susan Banahan	Susan.Banahan@noaa.gov
Nancy Craig	Nancy.Craig@noaa.gov
Michael J. Dowgiallo	Michael.Dowgiallo@noaa.gov
David Johnson	David.Johnson@noaa.gov
Danielle Luttenberg	Danielle.Luttenberg@noaa.gov
Julia Neander	Julia.Neander@noaa.gov
Karen Newton	Karen.Newton@noaa.gov
W. Lawrence Pugh	Larry.Pugh@noaa.gov
Kevin Sellner	Kevin.Sellner@noaa.gov
Beth Turner	Elizabeth.Turner@noaa.gov
John Wickham	John.Wickham@noaa.gov

CENTER FOR COASTAL FISHERIES HABITAT RESEARCH AT BEAUFORT (CCFHR)

101 Pivers Island Road
Beaufort, North Carolina 28516
Phone: (252) 728-8745
Fax: (252) 728- 8784
Acting Director: Don Hoss
Email: Don.Hoss@noaa.gov
Secretary: Jeanie Fulford

Staff	Email Address
John Burke	John.Burke@noaa.gov
Dave Colby	Dave.Colby@noaa.gov
Carolyn Currin	Carolyn.Currin@noaa.gov
Dave Evans	Dave.Evans@noaa.gov
Randy Ferguson	Randy.Ferguson@noaa.gov
Don Field	Don.Field@noaa.gov
Mark Fonseca	Mark.Fonseca@noaa.gov
Jeff Govoni	Jeff.Govoni@noaa.gov
Pete Hansen	Pete.Hansen@noaa.gov
Jon Hare	Jon.Hare@noaa.gov
Don Hoss	Don.Hoss@noaa.gov
Sue Huntsman	Sue.Huntsman@noaa.gov
Jud Kenworthy	Jud.Kenworthy@noaa.gov
Dave Peters	Dave.Peters@noaa.gov
Allyn Powell	Allyn.Powel@noaa.gov
Roger Schecter	Roger.Schecter@noaa.gov
Larry Settle	Larry.Settle@noaa.gov
Bill Sunda	Bill.Sunda@noaa.gov
Pat Tester	Pat.Tester@noaa.gov
Gordon Thayer	Gordon.Thayer@noaa.gov
Dorsey Worthy	Dorsey.Worthy@noaa.gov

CENTER FOR COASTAL ENVIRONMENTAL HEALTH & BIOMOLECULAR RESEARCH AT CHARLESTON (CCEHBR)

219 Fort Johnson Road
Charleston, South Carolina 29412-9110
Phone: (843) 762-8500
Fax: (843) 762-8700
Director: Sylvia Galloway
Email: Sylvia.Galloway@noaa.gov
Secretary: Jan Carson

Staff	**Email Address**
Marty Ball	Marty.Ball@noaa.gov
Paul Becker*	Paul.Becker@noaa.gov
Mark Busman	Mark.Busman@noaa.gov
Paul Comar	Paul.Comar@noaa.gov
Marie DeLorenzo	Marie.Delorenzo@noaa.gov
Greg Doucette	Greg.Doucette@noaa.gov
Pat Fair	Pat.Fair@noaa.gov
Mike Fulton	Mike.Fulton@noaa.gov
Sylvia Galloway	Sylvia.Galloway@noaa.gov
Dan Johnson	Dan.Johnson@noaa.gov
Carl Kinerd	Carl.Kinerd@noaa.gov
Peter Key	Pete.Key@noaa.gov
Malcolm Meaburn	Malcolm.Meaburn@noaa.gov
Steve Morton	Steve.Morton@noaa.gov
Peter Moeller	Peter.Moeller@noaa.gov
John Ramsdell	John.Ramsdell@noaa.gov
Patty Rosel	Patty.Rosel@noaa.gov
Gloria Seaborn	Gloria.Seaborn@noaa.gov
Geoff Scott	Geoff.Scott@noaa.gov
Tom Siewicki	Tom.Siewicki@noaa.gov
Fran Van Dolah	Fran.VanDolah@noaa.gov
Cheryl Woodley	Cheryl.Woodley@noaa.gov

*NIST Scientist

CENTER FOR COASTAL ENVIRONMENTAL HEALTH & BIOMOLECULAR RESEARCH AT OXFORD (CCEHBR)

904 South Morris Street
Oxford, Maryland 21654
Phone: (410) 226-5193
Fax: (410) 226-5925
Officer in Charge: Kilho Park
Email: Kilho.Park@noaa.gov
Secretary: Karen Hayman

Staff	**Email Address**
Fred Kern	Fred.Kern@noaa.gov
Jay Lewis	Jay.Lewis@noaa.gov
Shawn McLaughlin	Shawn.McLaughlin@noaa.gov
Gretchen Messick	Gretchen.Messick@noaa.gov
Kilho Park	Kilho.Park@noaa.gov

Volunteers

Carl Sinderman	Carl.Sinderman@noaa.gov
Aaron Rosenfield	Aaron.Rosenfield@noaa.gov

GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY (GLERL)

2205 Commonwealth Boulevard
Ann Arbor, Michigan 48105
Phone: (734) 741-2244
Fax: (734) 741-2003
Director: Steve Brandt
Email: Brandt@glerl.noaa.gov
Secretary: Renda Williams

Staff	**Email Address**
Raymond Assel	Assel@glerl.noaa.gov
Steve Brandt	Brandt@glerl.noaa.gov
Dima Beletsky *	Beletsky@glerl.noaa.gov
Thomas Croley	Croley@glerl.noaa.gov
Brian Eadie	Eadie@glerl.noaa.gov
Peter Landrum	Landrum@glerl.noaa.gov
Paul Liu	Liu@glerl.noaa.gov
Brent Lofgren	Lofgren@glerl.noaa.gov
Gerald Miller	Miller@glerl.noaa.gov
Thomas Nalepa	Nalepa@glerl.noaa.gov
Michael Quigley	Quigley@glerl.noaa.gov
Frank Quinn	Quinn@glerl.noaa.gov
David Reid	Reid@glerl.noaa.gov
John Robbins	Robbins@glerl.noaa.gov
James Saylor	Saylor@glerl.noaa.gov
Henry Vanderploeg	Vanderploeg@glerl.noaa.gov

* CILER Scientist
Cooperative Institute for Limnology and Ecosystems Research (CILER)
University of Michigan
2200 Bonisteel Boulevard
Ann Arbor, MI 48109-2099

NATIONAL OCEAN SERVICE

Office of the Assistant Administrator

Nancy Foster	Nancy.Foster@noaa.gov
Ted Lillestolen	Ted.Lillestolen@noaa.gov

National Geodetic Survey

Dennis Milbert	Dennis.Milbert@noaa.gov
Jim Lucas	Jim.Lucas@noaa.gov

Coast Survey

Bruce Parker	Bruce.Parker@noaa.gov

Office of Response & Restoration

Jean Snider	Jean.Snider@noaa.gov

Ocean & Coastal Resources Management

Helen Golde	Helen.Golde@noaa.gov
Peyton Robertson	Peyton.Robertson@noaa.gov
Lisa Symons	Lisa.Symons@noaa.gov

Coastal Services Center

Geno Olmi	Geno.Olmi@noaa.gov

Special Projects Office

Dan Farrow	Dan.Farrow@noaa.gov

International Program Office

Clement Lewsey	Clement.Lewsey@noaa.gov

Operational & Oceanographic Products & Services

Stephen Gill	Stephen.Gill@noaa.gov

Policy, Analysis, & Communication

Richard Edwing	Richard.Edwing@noaa.gov
Rebecca Smyth	Rebecca.Smyth@noaa.gov

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Policy & Strategic Planning
Ashley Chappell Ashley.Chappell@noaa.gov
Roger Griffis Roger.P.Griffis@noaa.gov

DUKE UNIVERSITY MARINE LAB
Richard Barber rbarber@duke.edu